SEWAGE AND INDUSTRIAL WASTES

(Formerly Sewage Works Journal)

JOURNAL of the FEDERATION OF SEWAGE AND INDUSTRIAL WASTES ASSOCIATIONS

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1956 YEARBOOK AND DIRECTORY

MARCH, 1956—VOL. 28, No. 3

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29TH ANNUAL MEETING

OF THE

FEDERATION OF SEWAGE AND INDUSTRIAL WASTES ASSOCIATIONS

IN CONJUNCTION WITH

CALIFORNIA SEWAGE AND INDUSTRIAL WASTES ASSOCIATION

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October 8-11, 1956

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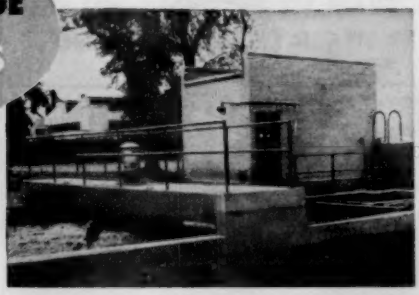

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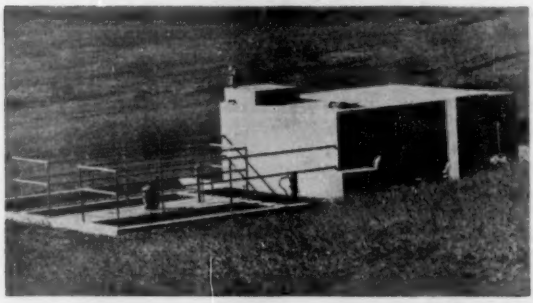

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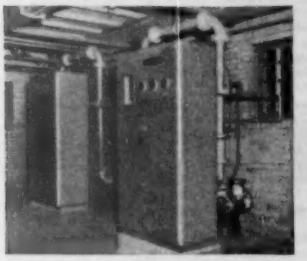

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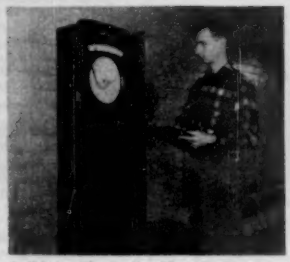

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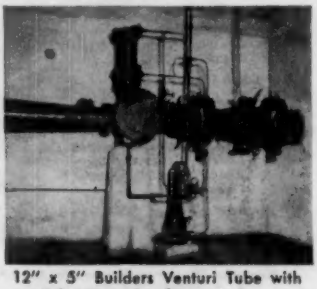

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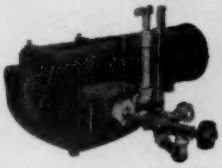

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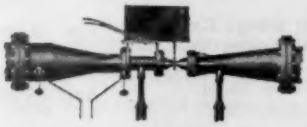

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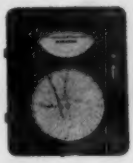

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Alabama Water and Sewage Assn.	Alabama Polytechnic Auburn, Ala.	June 4–6, 1956
Ohio Sewage and Industrial Wastes Treatment Conference	Hotel Carter Cleveland, Ohio	June 13–15, 1956
Institute of Sewage Purification	Harrogate, England	June 18–22, 1956
Central States Sewage and Industrial Wastes Assn.	Northland Hotel Green Bay, Wis.	June 20–22, 1956

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October 8–11, 1956

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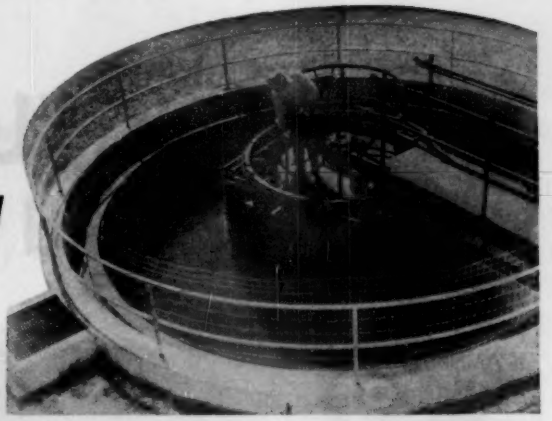

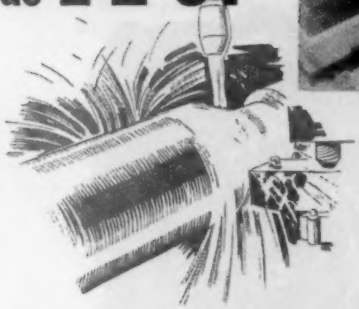

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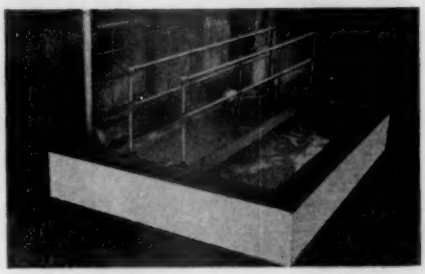

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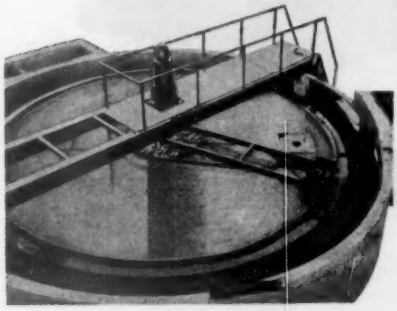

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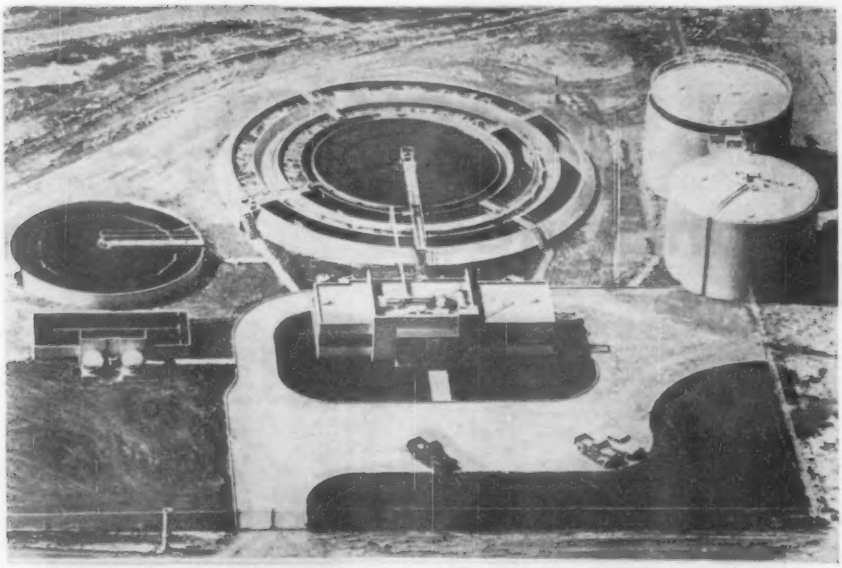


Engineers—Currie Engineering Company

Photo Credit—Dorr-Oliver

VAREC EQUIPMENT

safely controls surplus gas at this EL CAJON Sewage Plant

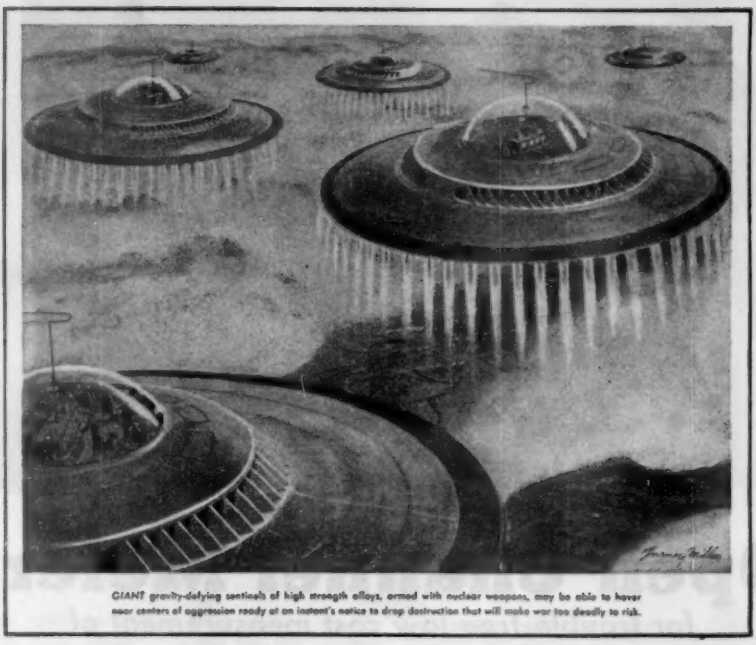
Like thousands of progressive cities in the United States and Canada; El Cajon, California, protects its modern sewage treatment plant with Varec Sewage Gas Controls and Safety Devices. These include Varec Flame Arrester, Drip Traps, Manometer, Flame Trap Assembly, Flame Checks, Pressure Regulator and Waste Gas Burner. Positive fire protection is assured by this type of installation—resulting in minimum insurance rates. Request Varec S-3 Catalog for full information.

"Varec"

VAPOR RECOVERY SYSTEMS COMPANY
2820 N. Alameda St., Compton, Calif.
Cable address: VAREC Compton California (U.S.A.) All Codes

S-12

Available from Authorized Sewage Equipment Agents throughout the U.S. and Canada



GIANT gravity-defying sentinels of high strength alloys, armed with nuclear weapons, may be able to hover near centers of aggression ready at an instant's notice to drop destruction that will make war too deadly to risk.

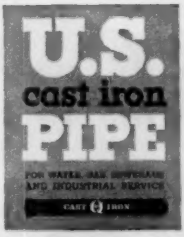
100 years from now...

WE MAY MAKE WAR IMPOSSIBLE!

Scientists, looking ahead, envisage a fabulous future...full of wonderful new products that will bring civilization a whole new era of progress. But, even then, our gas and water will still flow through the same dependable cast iron pipe being laid now.

Here's proof! Today, more than 60 American cities and towns are being efficiently served by the same cast iron water and gas mains laid over 100 years ago. What's more, modernized cast iron pipe...centrifugally cast and quality-controlled ...is even stronger, tougher, more serviceable.

U. S. Pipe is proud to be one of the leaders in a forward-looking industry whose service to the world is measured in centuries.



U. S. PIPE AND FOUNDRY COMPANY, General Office: Birmingham 2, Alabama

A WHOLLY INTEGRATED PRODUCER FROM MINES AND BLAST FURNACES TO FINISHED PIPE.

BAILEY

Open Channel Meters

for trouble-free low cost measurement of

Sewage, Industrial Wastes, Sludge, Irrigation, Water Supply

Bailey Meters offer these advantages—

1. Easy to Install and Maintain
2. Retain Accuracy
3. Self Cleaning
4. Adjustable Capacities
5. Totalize Multiple Flows
6. Chemical Feed Control
7. Flow and Ratio Controls
8. Low Cost

For further information on how Bailey Meters can meet your needs, ask for Bulletin M22-5.

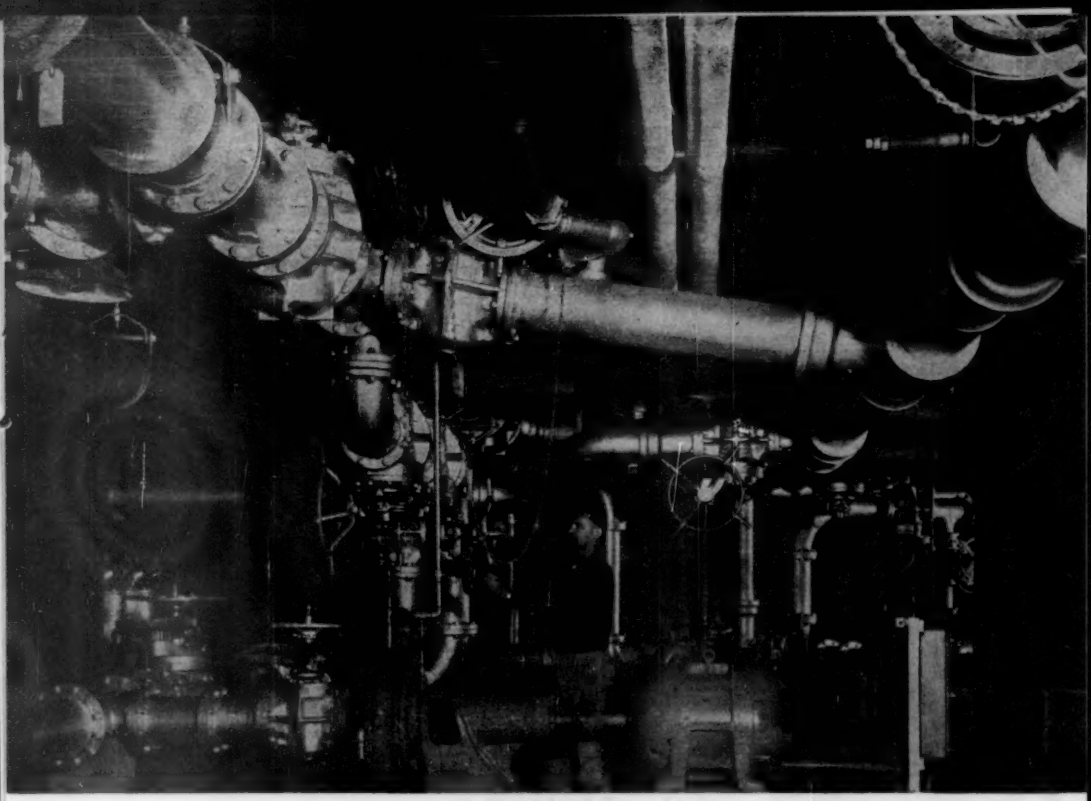
MU25

Bailey Meter Company

1066 Ivanhoe Road • Cleveland 10, Ohio

Meters and Controls for Sewage and Water

Venturi Tubes • Flumes • Weirs • Nozzles • Orifices • Direct Mechanical and Remotely Located Registers • Air-Operated, Electronic and Electric Controls



Are your hard-to-get at valves

Easy to Operate?

Rockwell-Nordstrom valves can be installed away up in the air or buried under the ground with complete assurance of operating ease and dependable closure. Two distinct features make such versatility in application possible. First: their quarter-turn operation allows simpler, more compact operating mechanisms. Second: pressurized lubricant "cushions" the tapered plug for instant, smooth rotation and ever-ready response.

Standard Rockwell accessories include double end chain wheels and wrenches, high head extensions, floor stands, water tight gear housings (expensive vaults aren't necessary with Rockwell-Nordstrom valves) and electric or cylinder operators.

No matter what your sewage or wastes plant requirements, there is a Rockwell-Nordstrom valve and operating accessory that will do the job better and at lower cost than any other combination you've ever used. Rockwell Manufacturing Company, Pittsburgh 8, Pa.

Canadian Valve Licensee: Peacock Brothers Limited.

ROCKWELL-
Nordstrom
VALVES

Lubricant Sealed for Positive Shut-Off
40th YEAR *of lubricated plug valve leadership*

SEND COUPON FOR MORE DETAILS

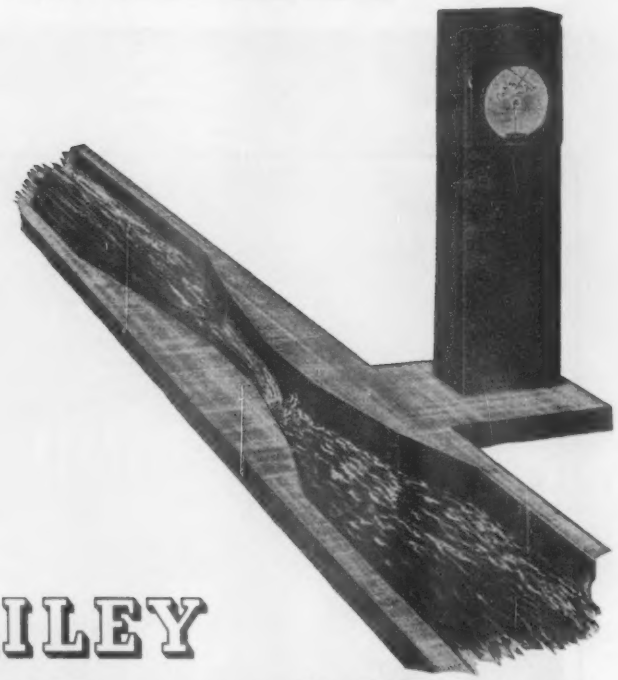
Rockwell Manufacturing Company
Pittsburgh 8, Pennsylvania

☐ Please send me Bulletin C-5200.
☐ Please have your sales engineer call.

Name_____ Title _____

Address_____

City_____ Zone____ State_____



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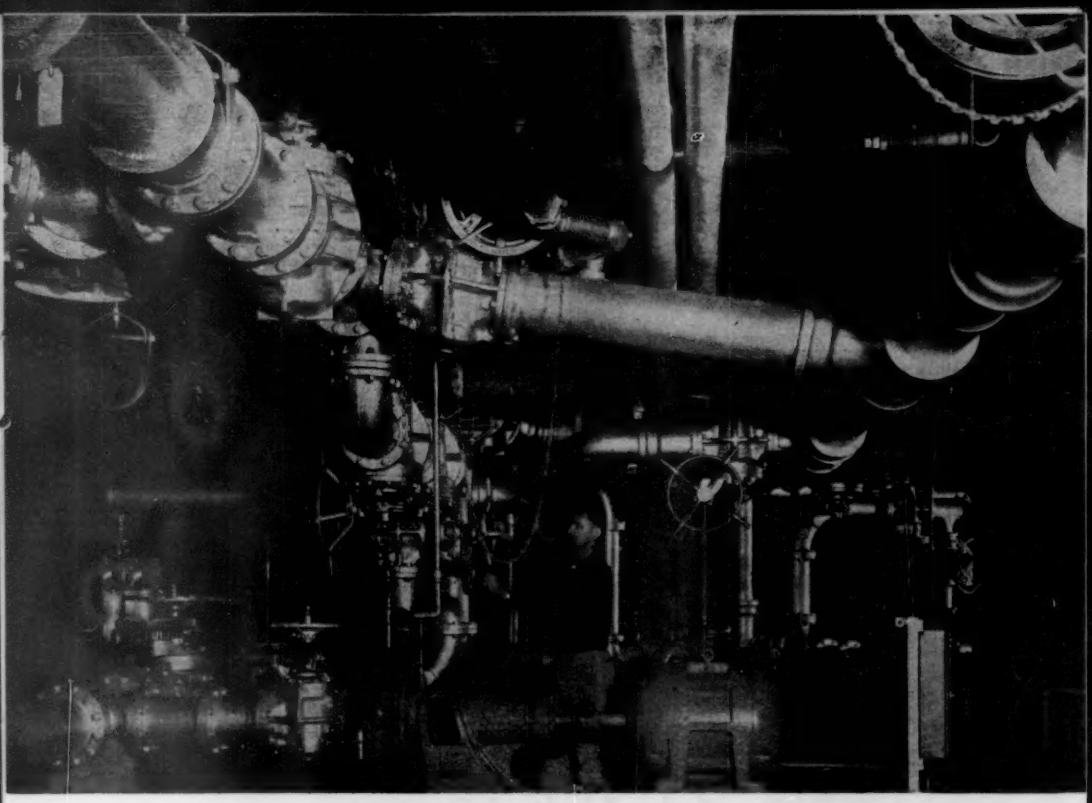

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Pittsburgh 8, Pennsylvania

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☐ Please have your sales engineer call.

Name_____ Title_____

Address_____

City_____ Zone____ State_____

The Chicago Sewage Disposal System

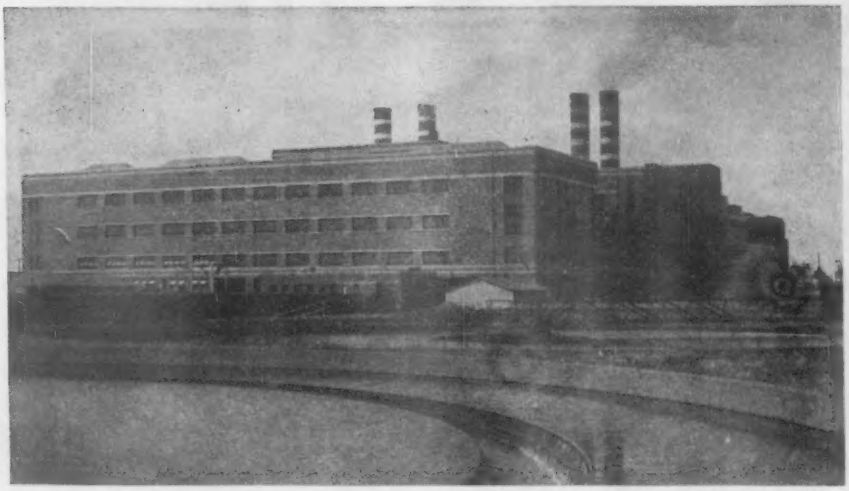


Photo courtesy CIVIL ENGINEERING

One of the 7 Civil Engineering Wonders of the United States

That's the expert opinion of the American Society of Civil Engineers. It happened October 20th, 1955, when the A.S.C.E. selected the country's seven modern wonders of civil engineering. (The other six: Colorado River Aqueduct... Empire State Building... Grand Coulee Dam... Hoover Dam... Panama Canal... San Francisco-Oakland Bay Bridge).

There's good reason why the Metropolitan Sanitary District of Greater Chicago should be so highly honored. For its Sewage Disposal System, constructed at a cost of many millions of dollars, is the largest of its kind anywhere in the world. And its construction involved exceptional achievements—such as the reversal of flow of the Chicago River, to prevent pollution of Lake Michigan, which is Chicago's fresh water source.

Some idea of the size of the facilities owned and operated by the Chicago Sanitary District may be gained from these figures: the system treats and disposes of the sewage from a population of 4,500,000 people . . . handles Chicago's industrial wastes, which add a population equivalent of 3,000,000 more. Its plants treat more than a billion gallons of sewage a day, and discharge a clear, safe effluent.

For twenty years, Combustion Engineering, and its Raymond Division, have served the Sanitary District of Chicago. Seventeen C-E Raymond Flash Drying Systems dry or incinerate the vast quantities of filter cake produced daily, and seven C-E Pulverized Fuel-Fired Boilers provide for steam requirements. C-E is proud of this long, continuous association with Chicago's Sewage Disposal System, and extends hearty congratulations for the recognition accorded it by the American Society of Civil Engineers.

COMBUSTION ENGINEERING C-E 8-899A

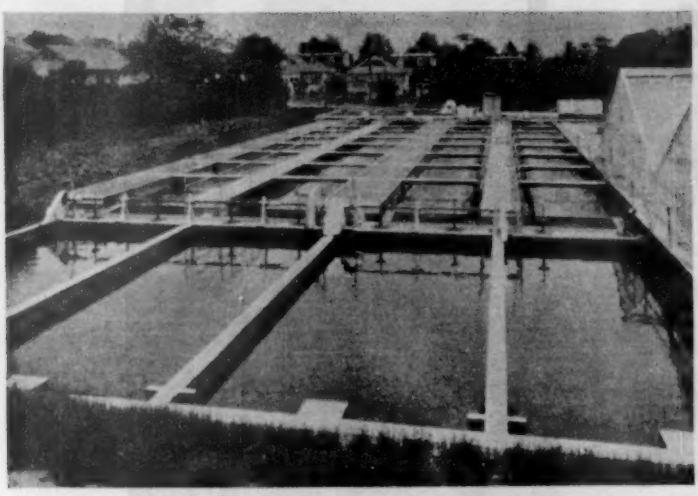
RAYMOND DIVISION

1315 North Branch Street, Chicago 22, Illinois

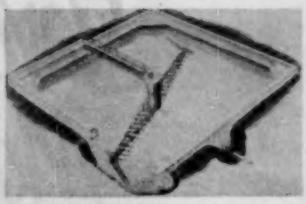
Eastern Office: 200 Madison Avenue, N. Y. 16, N. Y. *Western Office:* 510 West Sixth Street, Los Angeles 14, Calif.
Canada: Combustion Engineering-Superheater Ltd.

ALSO FLASH DRYING AND INCINERATION SYSTEMS FOR INDUSTRIAL WASTE DISPOSAL

Call on LINK-BELT for water, sewage and waste treatment equipment built to last



STRAIGHTLINE COLLECTORS for rectangular settling tanks. Peak-cap bearings, pivoted flights and Straightline action all contribute to top efficiency. *Chain in system shown installed in 1930 gave 15 years of continuous 24 hour service before replacement.*



CIRCULINE COLLECTORS for square or round tanks for quick, positive sludge and scum removal in shortest time without septicity.

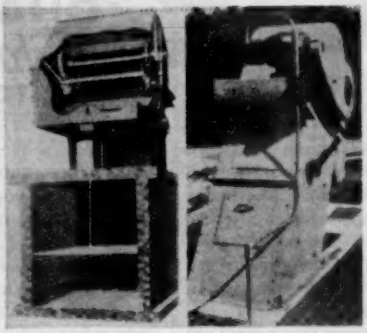
LIQUID SCREENS have proved efficient and economical for removing solids from industrial liquids. Available in several sizes with fine cloth.

ONE SOURCE . . . ONE RESPONSIBILITY

LONG life decides the eventual economy of sanitary waste treatment equipment. And after years of operation, Link-Belt systems in cities both large and small continue to provide highly effective water purification and sewage treatment service . . . with negligible maintenance expense.

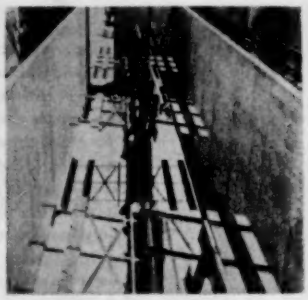
Link-Belt equipment has also been welcomed in industrial plants of all kinds — particularly in states having strict anti-pollution legislation. For Link-Belt equipment can dispose of wastes at lowest cost — recover by-products for highest profit.

Link-Belt offers you a broad line of top-quality equipment . . . plus engineering proficiency acquired in over 34 years' experience. Our specialists will be glad to work with your own engineers, chemists and consultants to bring you the finest in modern treatment methods. Call your nearest Link-Belt office for full information and catalogs on the Link-Belt products shown here.



THRU-CLEAN BAR SCREENS — Remove large floating particles from large volumes of water — thus protect other equipment.

TRITOR SCREENS — For small sewage treatment plants—remove both grit and screenings with one mechanism.



CHEMICAL MIXERS — Link-Belt builds Straightline (shown) and flash mixers. Efficiency is assured by operation at variable speed for maximum floc formation.

LINK-BELT

SANITARY ENGINEERING EQUIPMENT

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

19,777

Save Money

FROM THE
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with
CHAPMAN
Standard
SLUICE GATES

At the very beginning, Chapman Standard Sluice Gates save you money. In fact, they save money even before they're used.

In more than 300 types and sizes available, all component parts are standardized... *interchangeable.* You eliminate hit or miss installations. You get a sluice gate that meets *your* specifications. Fits perfectly at the lowest cost, because expensive and time consuming matchmaking and field alterations are eliminated.

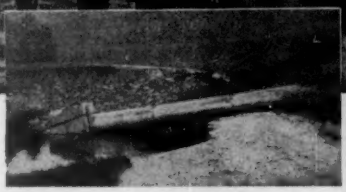
When installed, Chapman Standard Sluice Gates continue to save money. The standardized parts are easy to replace . . . easy to fit . . . without expensive repair or service.

For any requirement . . . high or low head, seating or unseating pressures, large or small water areas . . . Chapman Standard Sluice Gates will meet your demands both for price and cost. You can have them with manual, hydraulic or electric motor operation.

Read all about them in our Catalog 25-A . . . Sent immediately at your request.

THE CHAPMAN VALVE MFG. COMPANY
INDIAN ORCHARD, MASSACHUSETTS

THE LINE THAT HELD



At Waterbury, Conn., this Lock Joint Reinforced Concrete Cylinder Pipeline, undermined by flood waters, gave trouble-free service, alleviating a critical water shortage.

Although sections of this 48" Lock Joint water supply line for Hartford, Conn. were uncovered by the flood, it continued to give satisfactory service.

The destiny of England once hung on Wellington's "thin, red line" at the Battle of Waterloo. Daily your community's safety from fire and epidemic depends, to a large degree, on its water supply and sewage lines.

When the backwash of Hurricane Diane inundated western New England, the many Lock Joint installations in the area stood firm. These lines, in some cases the main source of water supply or of sanitary sewage disposal, continued to give trouble-free service even when uncovered and undercut by raging flood waters.

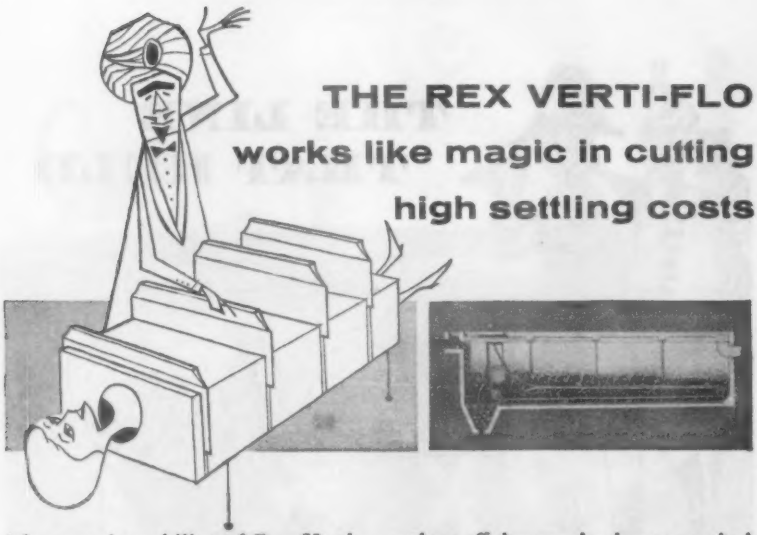
Such rugged pipe deserves your consideration. Its strength is evident, its initial high carrying capacity is permanent and its useful life is exceptionally long.

LOCK JOINT PIPE CO.

East Orange, New Jersey

Sales Offices: Chicago, Ill. • Columbia, S. C. • Denver, Col. • Detroit, Mich. • Hartford, Conn. • Kansas City, Mo.

Pressure • Water • Sewer • REINFORCED CONCRETE PIPE • Culvert • Subaqueous



THE REX VERTI-FLO works like magic in cutting high settling costs

The amazing ability of Rex Verti-Flo Clarifiers to reduce costs... assure clearer effluent... increase over-all plant efficiency... is almost magical. Actually the Verti-Flo design *divides* a horizontal-flow settling tank into a series of smaller, vertical-flow cells.

What does this unique design mean? It means more tank capacity—up to *four* times more than conventional settling tanks. In existing tanks, Verti-Flo will at least double your present capacity. In new construction, Verti-Flo® saves on both construction and equipment costs since you can plan for smaller tanks. Detention times are from one-fourth to one-half those required in conventional tanks and yet you get an effluent of maximum clarity.

Whether you specify equipment or operate a plant, you should know the facts about Rex Verti-Flo. Why not have the advantages of Rex® Verti-Flo in your plant? For complete details, mail the coupon today for your copy of Bulletin 52-77. You'll be happy you did.

These Verti-Flo users are getting increased efficiency... lower costs... clearer effluent

Fairmont, Minn.
U. S. Penitentiary, McNeil Island, Wash.
Ashland, Oregon
Roseburg, Oregon
Kansas State Penitentiary, Lansing, Kansas
Corvallis, Oregon
Florence, Oregon
Valencia, Venezuela
Pentagon Building Arlington, Virginia
Johns-Manville Corp. Finderne, New Jersey
Combined Locks Paper Co. Combined Locks, Wis.
Kohler Company Kohler, Wisconsin
Sweet Home, Oregon
Fort Wayne, Indiana
Belleview, Wash.
Washington Water Power Co. Clarkston, Wash.
Somerset, Penn.
Federal Reformatory for Women Alderson, W. Va.
Kirkland, Washington
Maynard Electric Steel Casting Company Milwaukee, Wisconsin
The Ruberoid Co. Bound Brook, N. J.
Wisconsin Car Wash Co. Milwaukee, Wisconsin

CHAIN BELT COMPANY
Milwaukee 1, Wis.

CHAIN Belt Company
4606 W. Greenfield Ave.
Milwaukee 1, Wis.

Send me my copy of informative Verti-Flo Bulletin No. 52-77.

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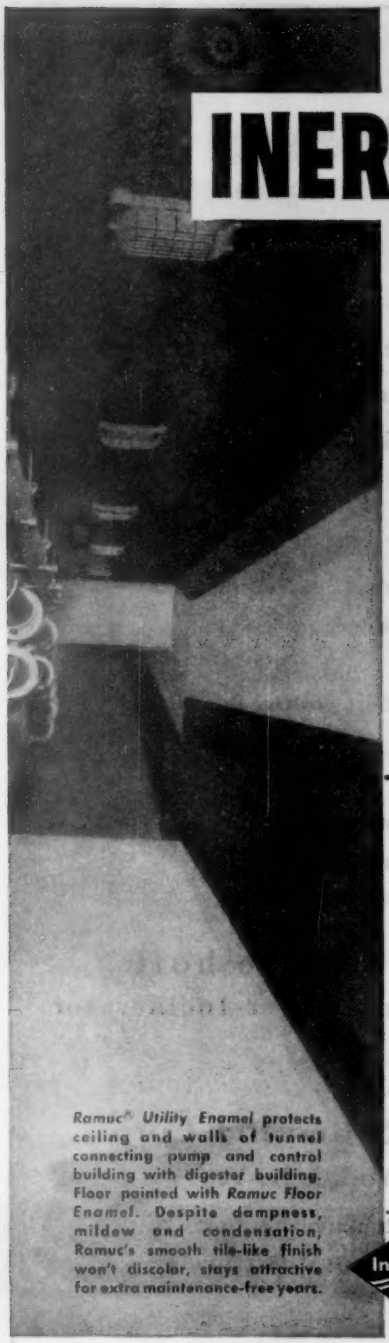
City.....*State*.....



Ramuc® Utility Enamel protects ceiling and walls of tunnel connecting pump and control building with digester building. Floor painted with *Ramuc Floor Enamel*. Despite dampness, mildew and condensation, Ramuc's smooth tile-like finish won't discolor, stays attractive for extra maintenance-free years.

Complete Protection with

INERTOL® PAINTS

Specified for new 9-MGD Westerly Sewage Plant, Altoona, Pennsylvania

Altoona, Pennsylvania, was one of the first U.S. cities to install and maintain proper sewage facilities. With the new, efficient Westerly plant, designed by Albright & Friel, Inc., Consulting Engineers, Philadelphia, Pa., Altoona continues to show outstanding progress in the sewage works field.

Inertol coatings specified for the Westerly plant assure long-term, low-cost protection ... easy-to-clean, attractive surfaces that withstand severe sewage plant conditions. Buy Inertol paints direct from the manufacturer. Shipment within three days from our plant, or from nearby warehouse stocks. For complete information about Inertol coatings, write today for *free* "Painting Guide"—an important tool for Design Engineers, Specification Writers and Plant Superintendents.

Ask about Rustarmor®, Inertol's new hygroscopically controlled rust-neutralizing paint.

SPECIFICATIONS FOR RAMUC UTILITY ENAMEL

A glossy chlorinated natural rubber-base coating in color for nonsubmerged concrete, steel and indoor wood surfaces.

CONCRETE SURFACES

Colors: Color chart 560.

Number of coats: One coat of *Ramuc Utility Enamel* over two coats of *Ramuc Utility Undercoater*. For a flat finish, apply two coats of *Ramuc Utility Enamel Flat* to bare masonry—omit undercoater.

Coverage: 250 sq. ft. per gal. per coat.

Approximate mil thickness per coat: 1.2.

Drying time: 24 hours.

Primer: *Ramuc Utility Undercoater* (2 coats).

Thinners: *Inertol Thinner 2000-A* for brushing; *2000* for spraying.

Application: Brushing: *Ramuc Utility Enamel*—brush type: as furnished. Spraying: *Ramuc Utility Enamel*—spray type: add sufficient *Thinner 2000* for proper atomization.

(Write for Ramuc specifications for steel surfaces, and for Ramuc Floor Enamel specifications)

Inertol

INERTOL CO., INC.

A complete line of quality coatings for sewage, industrial wastes and water plants.

482 Frelinghuysen Avenue
Newark 5, N. J.

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San Francisco 7, Calif.

Why?

. . is the Nichols Herreshoff Dryer-Incinerator being used by more and more municipalities?

Because . . the Herreshoff furnace will burn grits, grease, screenings, skimmings and sludge.

Because . . it offers positive fly-ash and odor control

Because . . it will dry or burn sludge with unsurpassed efficiency.

Nichols Herreshoff
Multiple Hearth Dryer-Incinerator

Nichols Engineering & Research Corp.
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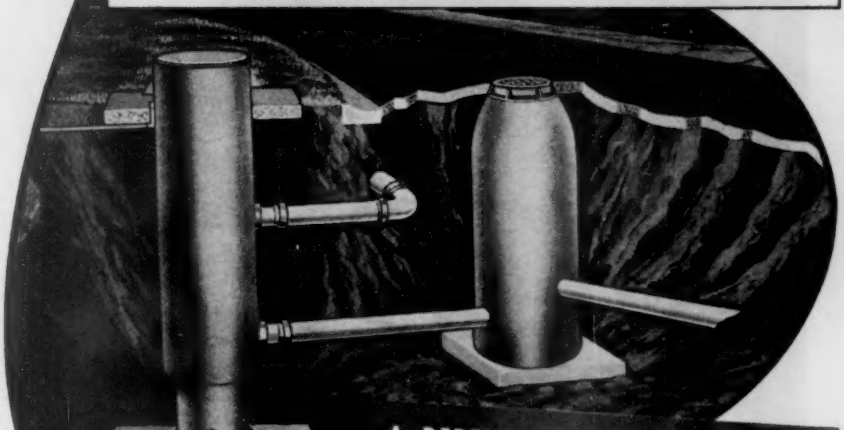
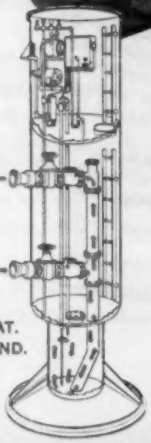
1477 Sherbrooke St. W., Montreal 25, Canada

Have you considered... The Smith & Loveless "MON-O-JECT"?



A DEPENDABLE FACTORY-BUILT SINGLE PNEUMATIC EJECTOR SEWAGE LIFT STATION ... AT THE LOWEST COST



PAT. PEND.

FOR FACTORIES • SCHOOLS • MOTELS • AND SMALL SUB-DIVISIONS

CAPACITIES: 20 G. P. M. to 100 G. P. M.

- **FACTORY ASSEMBLED AND TESTED**
- **COMPLETELY AUTOMATIC**
- **TESTED AND PROVEN IN SERVICE**
- **EASILY AND QUICKLY INSTALLED**
- **MINIMUM MAINTENANCE**
- **UNDERGROUND INSTALLATION ELIMINATES UNSIGHTLY PUMP HOUSE**

For Job Recommendations, complete specifications, and drawings-all part of the latest edition of the 100 page Smith & Loveless pump station Data Manual ....

WRITE DEPARTMENT 30

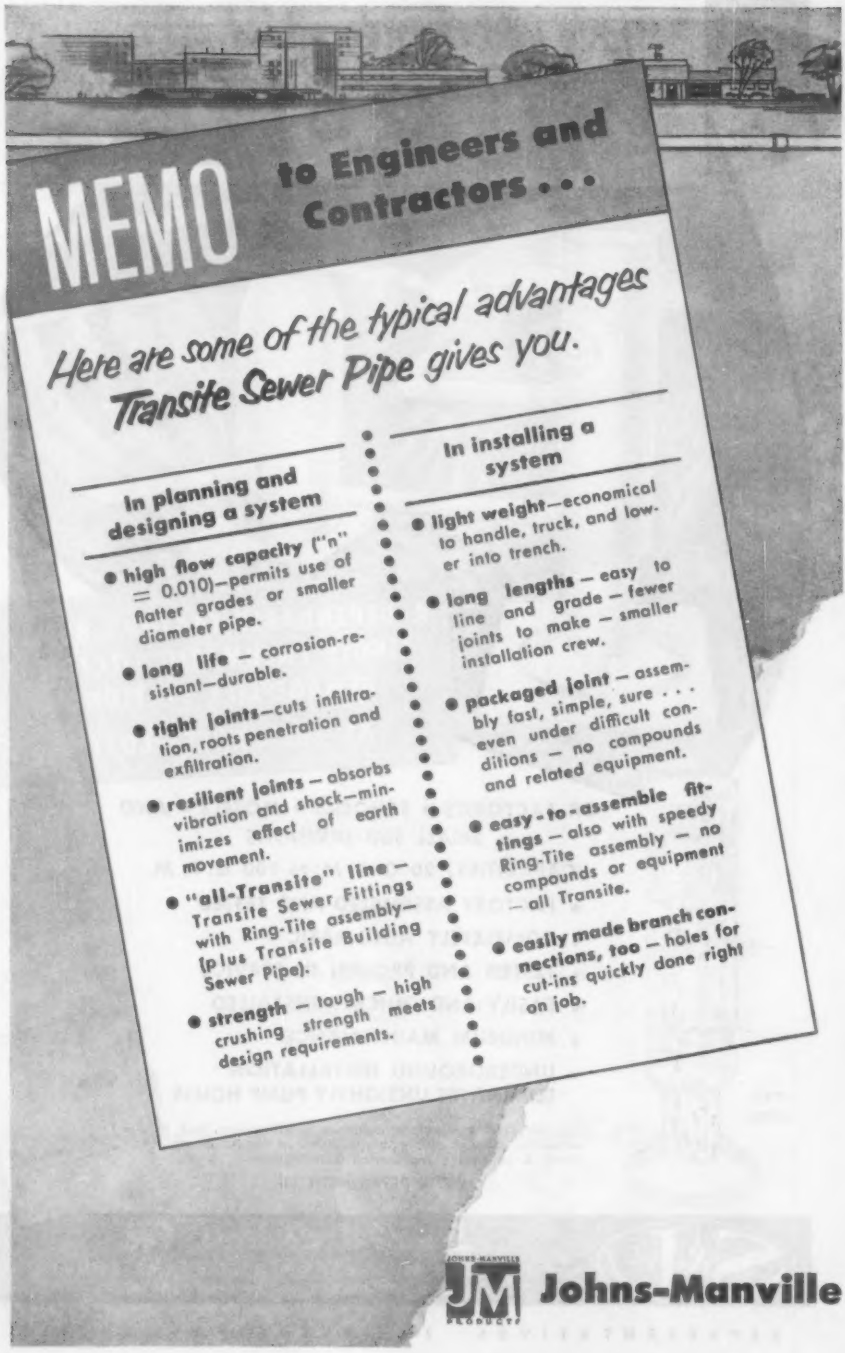
S&L

Smith & Loveless, Inc.

P. O. BOX 8172 • KANSAS CITY, MISSOURI

MANUFACTURING PLANT MERRIAM, KANSAS

REPRESENTATIVES IN PRINCIPAL CITIES


MEMO to Engineers and Contractors . . .
Here are some of the typical advantages Transite Sewer Pipe gives you.
In planning and designing a system
● high flow capacity ("n" = 0.010)—permits use of flatter grades or smaller diameter pipe.
● long life — corrosion-resistant—durable.
● tight joints—cuts infiltration, roots penetration and exfiltration.
● resilient joints — absorbs vibration and shock—minimizes effect of earth movement.
● "all-Transite" line — Transite Sewer Fittings with Ring-Tite assembly—(plus Transite Building Sewer Pipe).
● strength — tough — high crushing strength meets design requirements.
In installing a system
● light weight—economical to handle, truck, and lower into trench.
● long lengths — easy to line and grade — fewer joints to make — smaller installation crew.
● packaged joint — assembly fast, simple, sure . . . even under difficult conditions — no compounds and related equipment.
● easy-to-assemble fittings — also with speedy Ring-Tite assembly — no compounds or equipment — all Transite.
● easily made branch connections, too — holes for cut-ins quickly done right on job.
JOHNS-MANVILLE PRODUCTS
Johns-Manville

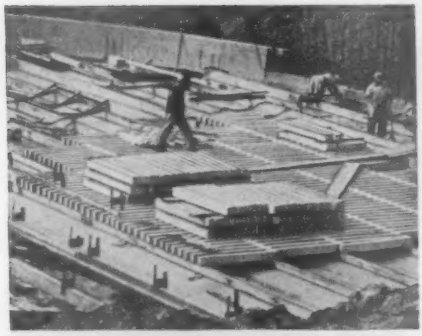
Select

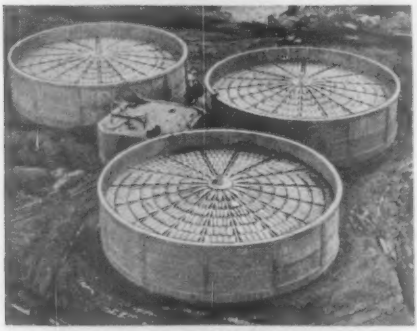
Transite® for more economical, tighter sewerage systems . . .

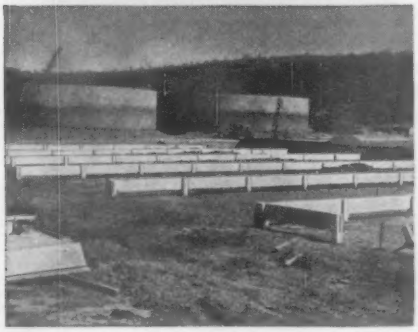
WHETHER a new sewerage system is being planned or additions to an existing one are being made . . . engineer and contractor alike will find a combination of qualities in performance-proved Transite Sewer Pipe that will fit their individual needs. They will find this holds true whether the local conditions call for (a) tight joints to protect against root growth and infiltration of ground water or (b) the strength and flow characteristics that mean definite savings in the design stage, during trenching and installation, and in operation as well.

For further information about Transite Sewer Pipe, write for Booklet TR-165A, Johns-Manville, Box 60, N. Y. 16, N. Y.

TRANSITE SEWER PIPE
with the RING-TITE® Coupling







Precast

CONCRETE UNITS

offer many advantages for Modern Sewage Treatment Works

Precast concrete units are being used in many sewage treatment plant facilities. There's a good reason. They offer all the advantages of conventional concrete construction—plus speed, economy and easy handling. Illustrated here are four typical recent examples:

FILTER UNDERDRAINS of the six trickling filters in the East Providence, R. I. Sewage Treatment Plant are precast, reinforced concrete beams (top photo). Because of concrete's great strength they also serve as cribbing to support the weight of the crushed traprock filter medium.

DIGESTER COVERS in the East Providence plant (second photo) are 2-in. thick, tongue-and-groove precast concrete planks. Concrete resists rot in a damp atmosphere, assures positive closure.

Covers for the digester tanks of the Benton Harbor-St. Joseph, Mich. Sewage Treatment Plant (third photo) are short slabs of precast concrete that rest on purlins connecting radial girders. Crevices between slabs are calked with mastic. Covers are 80 ft. in diameter.

SLUDGE BED PLANKS AND POSTS in Elmira, N. Y. Sewage Treatment Plant are precast concrete units (bottom photo). Durable precast concrete units withstand a lifetime of weathering and freeze-thaw cycles in such installations.

Precast concrete construction is moderate in first cost, requires little maintenance, serves for years. The result is ***low annual cost*** construction.

Write for a free illustrated booklet, *"Sewage Treatment Works."* It is distributed only in the U. S. and Canada.

PORTLAND CEMENT ASSOCIATION

Dept. 3-76, 33 W. Grand Ave., Chicago 10, Ill.

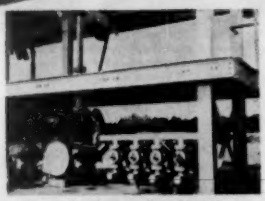
A national organization to improve and extend the uses of portland cement and concrete . . . through scientific research and engineering field work

That's the formula of success behind acf Rectangular Port Valves! Because they have a port area at least equal to the pipe itself... turbulence and loss of head pressure are held to a minimum... even when handling heavy slurries and other viscous ladings.

All acf *Cylindrical* Lubricated Plug Valves... both those with rectangular and round port openings ...feature split-second, quarter-turn shut off that meets the rigid control requirements in the petroleum, natural gas, and processing industries. Maintenance is especially low because they are fitted with TEFLON® gaskets to prevent head leakage, and have no line seats exposed to fluid flow.

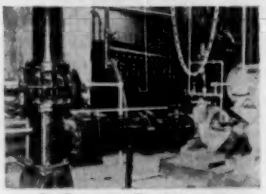
ACT NOW TO KEEP DOWN VALVE MAINTENANCE COSTS!

Representatives in 50 Principal Cities. Write for Descriptive Catalog 5-SI, acf Industries, Incorporated, Valve Division, 1501 E. Ferry Ave., Detroit 11, Mich.



On Petroleum Applications

In Chemical Plants



In Sewage Treatment

acf CYLINDRICAL FULL PIPE AREA PLUG VALVES

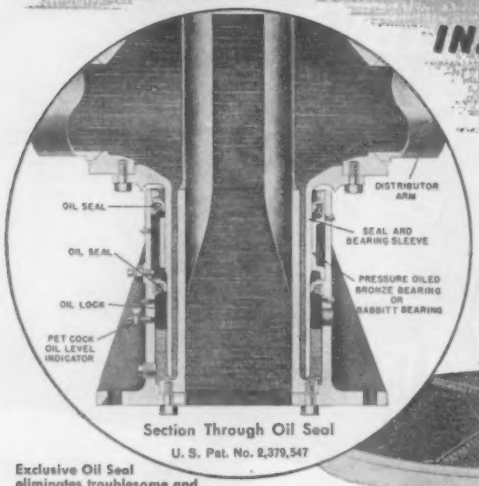
American DESIGN FEATURES

INSURE

UNIFORM DISTRIBUTION

EFFICIENT CONTINUOUS OPERATION

MINIMUM MAINTENANCE



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U. S. Pat. No. 2,379,547

Exclusive Oil Seal eliminates troublesome and costly mercury, completely protects bearing surfaces, and will not blow out under excessive heads.

Reaction Drive and Positive Drive

ROTARY DISTRIBUTORS

Hundreds of installations have proved the advantages of *American* Rotary Distributors. This approval by consulting engineers is based on economy of initial cost, structural strength and durability, superior liquid distribution, applicability to wide ranges of flow and available head, and minimum maintenance. Inherent design features reduce hydraulic-head losses to a minimum, and provide for maximum utilization of available hydraulic head in performance of useful work. *Every oil seal unit installed has given excellent, trouble-free service!* Available in a wide range of both Reaction-Drive and Motor-Driven Positive-Drive Distributors to meet all variations of actual field conditions—for rapid or standard rate waste filters, sand filters, or for water aeration. *Utilize the experience of American engineers.*

For helpful data and design details, write for Technical Supplement RD

A Complete Line of Pumps and Process Equipment for Sewage and Industrial Waste Treatment.

AMERICAN WELL WORKS

IN OUR 80TH YEAR
110 North Broadway
AURORA, ILLINOIS

Pumping, Sewage Treatment, and Water Purification Equipment
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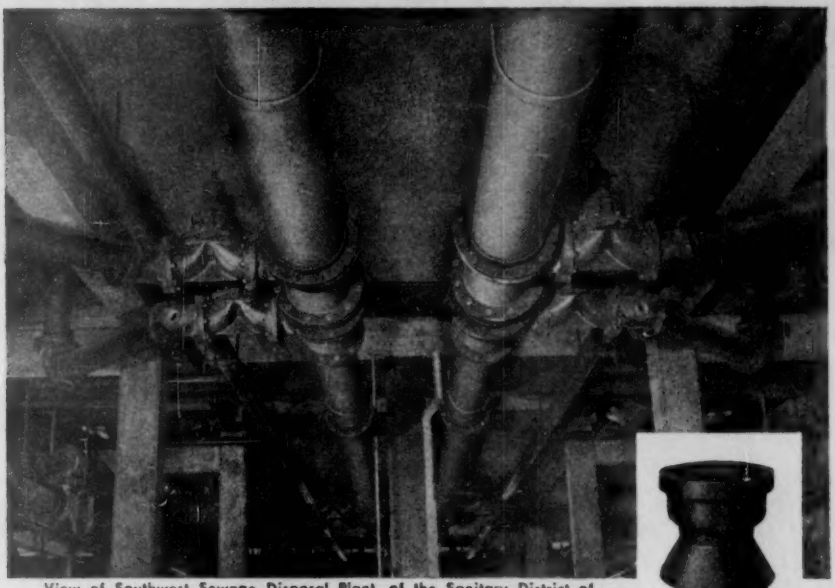

View of Southwest Sewage Disposal Plant, of the Sanitary District of Chicago, Stickney, Illinois . . where Clow Cast Iron Pipe was furnished to meet exact requirements.

Clow cast iron pipe, fittings, valves and specials for sewage plant replacements or new installations

• James B. Clow & Sons with their many years of experience as manufacturers of Cast Iron Pipe and Special Castings for Filtration and Sewage Disposal Plants know the difficult piping problems that continually face the sanitary engineer. Clow shops are completely equipped with the latest machinery. Clow's skilled workmen will produce pipe and specials to your exact specifications. Pipe can be furnished flange and flange, flange and bell, flange and plain end or with mechanical joint and plain end—in sizes 3 through 24 inches in laying lengths up to 18 feet.

CLOW (Threaded) Cast Iron Pipe

Clow also manufactures (threaded) Cast Iron Pipe in steel pipe sizes 3 through 10 inches which has the same outside diameter as common steel pipe. This pipe can be cut, threaded and fitted on the job with ordinary tools of the piping trade.

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Subsidiaries:
Eddy Valve Co., Waterford, N. Y.
Iowa Valve Co., Oskaloosa, Iowa

Comminutor installation serves 7 years with only routine maintenance

In Madison-Chatham Sewage Treatment Plant, money saved by low installation and maintenance costs helps pay for Worthington comminutor and other public works.

"Since 1948, when our Worthington comminutor was installed, it has operated successfully with only routine maintenance. The comminutor's reliability has proved a real blessing for our plant operation."

So says Ed Molitor, Plant Superintendent, about the 25-inch comminutor in service at Madison-Chatham, N. J., Joint-Meeting Sewage Treatment Plant.

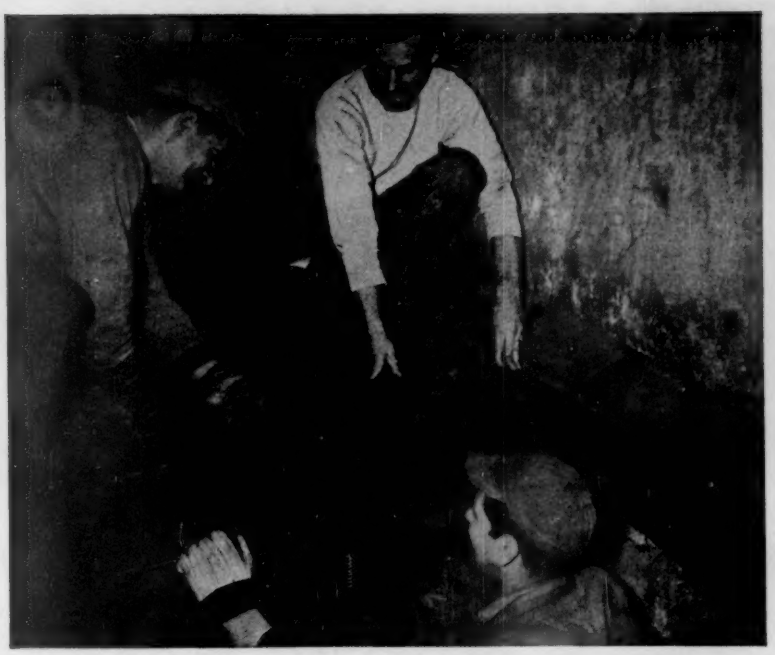
Mr. Molitor isn't alone in his opinion of the rugged Worthington comminutor. We've had similar reports wherever they're used—and that covers the country.

Learn about all the advantages of the Worthington comminutor. Contact your nearest Worthington District Office or write today for Comminutor Engineering Manual, W-317-B17, Worthington Corporation, A&SP-Public Works, Harrison, N. J.

WORTHINGTON

ALL MAJOR PUBLIC WORKS EQUIPMENT UNDER ONE RESPONSIBILITY

WATER WORKS PUMPS • SEWAGE PUMPS • COMMINUTORS • VERTICAL TURBINE PUMPS • VACUUM PUMPS



SCREENS:

EASILY FABRICATED OF EVERDUR FOR EXTRA CORROSION RESISTANCE

Fabricated of Everdur* Copper-Silicon Alloys, this sewage screen offers years of protection against corrosion at all stages of sewage treatment. Everdur alloys are the standard for equipment where high corrosion resistance must be incorporated into readily fabricated, lightweight structures.

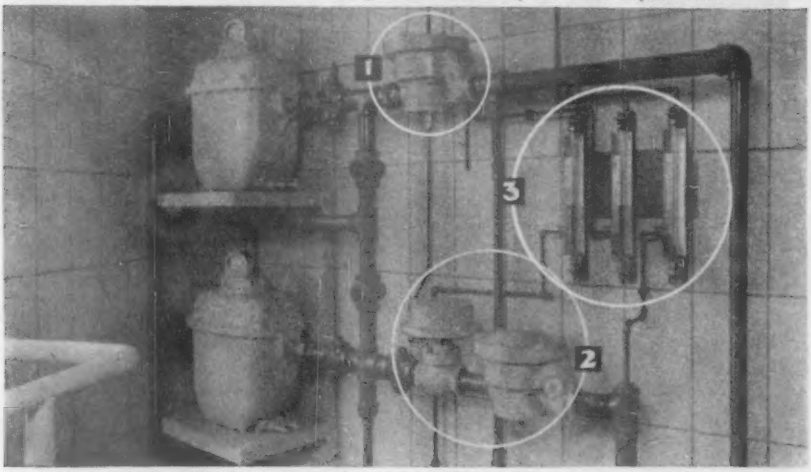
Everdur applications include gates, guides and bolts, valve and gate stems, weirs, float chambers, troughs, manhole steps and electrical conduit. These highly corrosion-resistant alloys are characterized by great strength and excellent working properties. Depending on which alloy is used, Everdur may be worked hot or cold, welded, machined, forged or cast and is available in plates, sheets, rods, tubes, electrical conduit and casting ingots.

If you would like detailed information for specific applications or designs, the services of our Technical Department are always available to you. Our Publication E-11 describes Everdur Alloys and applications in detail. Write for it. The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

*Reg. U. S. Pat. Off. 21134A

EVERDUR
ANACONDA®
COPPER-SILICON ALLOYS
STRONG • WELDABLE • WORKABLE
CORROSION-RESISTANT

PFT Gas Safety Equipment in the Control Building at the new Morris plant. See description below.



At Morris, Illinois . . .

A new plant equips for maximum protection

WITH PFT GAS SAFETY EQUIPMENT

The modern primary sewage treatment plant shown here began operations at Morris in March, 1955. Designed for a population of 9,600, it incorporates many features of "Controlled Digestion" in addition to a complete PFT gas safety system! Among the safety equipment items are:

(1) *PFT Flame Trap*—a heavy cast iron housing with aluminum flame arrester element prevents passage of flame. A thermal valve closes automatically at critical temperatures.

(2) *PFT Pressure Relief with Flame Trap*—the same flame trap features plus a pressure relief with diaphragm control. Maintains a safe, constant pressure at the digester and in the gas distribution system.

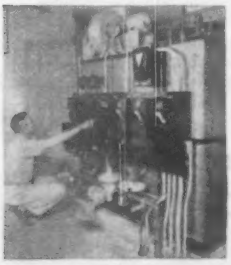
(3) *PFT Gas Pressure Gauge*—a 3 scale gauge indicates the pressure in various parts of the gas piping system. Top of gauge connects to vent manifold with flame checks.

PFT Drip Traps—four 2 qt. traps provide safe removal of condensate formed by warm gas passing through cooler piping.

Waste Gas Burner—an effective device that safely burns off all excess gas and prevents odor nuisance.

Additional equipment at the Morris plant includes: *PFT Floating Cover* for the 40' digester; *PFT Heater & Heat Exchanger; PFT Supernatant Selector and Gauge* unit.

Morris' city officials and consulting engineers have created a fine plant that serves efficiently and economically. PFT is proud to be associated with this modern sewage system.



Plant Superintendent G. B. Reagen checks operation of the PFT #250 Heater & Heat Exchanger.

Design of plants by / *Baxter & Woodman, Civil & Sanitary Engineers, Crystal Lake, Illinois*

P.F.T.

waste treatment equipment exclusively since 1893

PACIFIC FLUSH TANK CO.

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For Permanent, Economical Sewers and Drains

INDUSTRY CHOOSES CLAY PIPE

FAIRCHILD ENGINE DIVISION installed more than 23,000 feet of Vitrified Clay Pipe sewers and drains recently to serve the company's new $5 million plant at Deer Park, N.Y. The lines will carry many types of industrial wastes, including hard-to-handle process drainings from machines in the plant.

Like thousands of other manufacturing companies over the country, Fairchild is building for the future. You can see the foresight of this planning in the choice of Vitrified Clay Pipe for sewerage and drainage lines. Corrosive industrial waste can't affect it. Acid sewer conditions can't disintegrate it. Time can't weaken it. Clay Pipe is the one sewerage material that *never wears out.* For permanent sewers and drains—at lowest cost per year of service—always specify Vitrified Clay Pipe. It's guaranteed for 50 years.

DESIGNED AND CONSTRUCTED by the Austin Company. Job Superintendent: Walter Michaelson

Vitrified CLAY PIPE

NATIONAL CLAY PIPE MANUFACTURERS, INC.
1820 N. Street, N.W., Washington 6, D. C.

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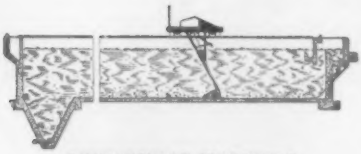
Progress in Public Health - Through Clay Pipe Research

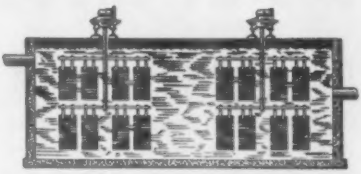
C-1065-1A

WATER, SEWAGE AND TRADE-WASTE TREATING EQUIPMENT



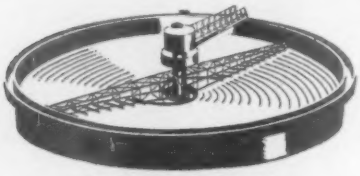
RECTANGULAR CLARIFIERS

Especially suited for limited spaces or where sludge delivery is desired at one end of the tank. A traveling scraper and skimmer carriage removes settled solids from the tank bottom and scum from the top.



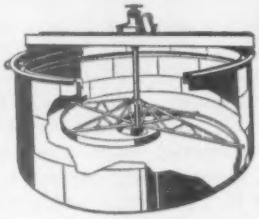
FLOCCULATING UNITS

Slowly rotating paddles on vertical shafts bring the small flocs into contact to form larger masses and hasten precipitation.



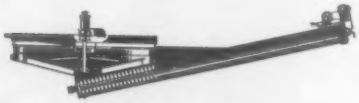
CIRCULAR CLARIFIERS

Hardinge Circular Clarifiers are available in sizes up to 200′ diameter, either center-column or beam supported for steel, concrete, wood or tile tanks. Sludge scrapers remove settled solids rapidly through central underflow discharge.



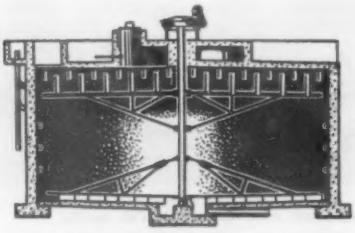
"AUTO-RAISE" THICKENERS

For removal of fine suspended solids from supply water, waste water and sewage. "Auto-Raise" mechanism prevents scraper breakage. Manual or power raise supplements "Auto-Raise." Replaceable ring-type ball bearing support for rotating mechanism. Spiral rakes for maximum underflow density.



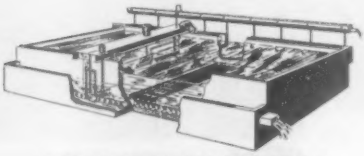
HYDRO-CLASSIFIERS

A large-volume classifier for rapid separation of coarse and fine suspended solids. Frequently used for by-product recovery from waste water.



DIGESTERS

Sludge scrapers and scum breaker arms prevent scum accumulation, insure uniform gas production. Emit a dense digested sludge.



AUTOMATIC BACKWASH FILTERS

For high removal of non-settling or slow settling suspended matter. Self-cleaning sand bed. No shut-down necessary for backwashing. Traveling backwash mechanism.

Write for Bulletin 35-D-16

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Zinc-Coated Armco Sewer Serves 49 Years ... So Far

This Armco Sewer, installed in 1907, is still giving satisfactory service today.

Armco's first sewer structures had only a galvanized coating to protect the base metal from corrosion and erosion. Sewer pictured is one of these early installations. Since then Armco developed ASBESTOS-BONDED Pipe, having asbestos fibers embedded in the zinc and coated with a special asphalt to provide complete and lasting protection, even when exposed to highly corrosive industrial wastes.

So ask yourself this question: *"If a sewer with only a galvanized coating is still serving after 49 years, how long will an Armco ASBESTOS-BONDED Sewer last?"*

Quite frankly, we can only guess.

To illustrate, a 42-inch-diameter Armco ASBESTOS-BONDED Sewer was installed in 1940 at a blast furnace in Hamilton, Ohio. It carries sanitary sewage as well as an extremely corrosive effluent from the blast furnace. Temperature of the water at the discharge end is above 100°F the year around. Inspected recently, there was no noticeable change in its condition.

And that's the problem. Installed Armco ASBESTOS-BONDED Sewers haven't shown enough signs of aging to even estimate the expected service life!

For more data, write us, describing your sewer problem. Also ask about other Armco Structures that solve various problems of corrosion, erosion, and flow on flat slopes. Armco Drainage & Metal Products, Inc., 3966 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation.

Armco Sewer Structures

ARMCO®

THE COILFILTER

Sanitary Engineers' Notebook

MEMO:

Most sewage sludges must be chemically coagulated prior to dewatering, so that filterable flocs replace slimy solids. The chemicals most frequently used are ferric chloride and high calcium hydrated lime. These are added and mixed with the sludge in a sludge conditioning tank, which should be located as close as possible to the COILFILTER, so as to minimize degradation of the flocculated sludge entering the filter vat.

When digested sludge is to be elutriated, it has been common practice to design the sludge dewatering installation for ferric conditioning only. Recently, however, we have encountered several elutriated sludges which dewater more economically when conditioned with lime in conjunction with the ferric salt. It therefore seems desirable to provide space for possible future addition of lime feeding equipment in such installations.

For plants with two or more Coilfilters, it is generally preferable to use one conditioning tank with each filter. This permits optimum control of conditioning, as well as minimum pipe runs to the filters.

Chemical feed equipment should be simple yet reliable. Manual control of output is preferable to automatic control. We have had remarkable success with Vanton pumps for ferric chloride, and our own 2" diaphragm slurry pumps for lime feeding. When equipped with variable speed drives in the proper speed range, these make excellent feed and metering pumps.

KOMLINE-SANDERSON ENGINEERING CORPORATION
PEAPACK, NEW JERSEY

Manufacturers of COILFILTER *sludge vacuum filters*

THIS IS THE CAVITATOR

- *for low-cost treatment of domestic sewage and industrial wastes*
- *ideal for small communities . . subdivisions . . motels . . resorts . . schools . . industrial plants*

Here are 9 reasons why the CAVITATOR is better:

1 Purification efficiency is equal to or better than that obtained by means of conventional equipment for the activated sludge process. All Cavitator systems meet State Board of Health requirements.

2 Oxygen transfer efficiency is 44% . . . much higher than most conventional equipment which has efficiencies of 5 to 10%.

3 Only 135 cubic feet of air is required per pound of B.O.D. removed (domestic sewage) as compared to 800 to 1000 cubic feet necessary for other types of equipment.

4 Original cost is low compared to any other type system, but purification is equal to that of the best activated sludge installations. Cavitation equipment is built to stand up under years of demanding service.

5 Aeration periods are shorter . . . approximately four hours for average maximum flow. This means smaller aeration tanks can be used . . . another feature which contributes to lower first costs.

6 No blowers or compressors are required. There are no diffusion tubes nor plates to be installed . . . and maintained. There is nothing to clog. The simple mechanism requires the minimum of maintenance and attention.

7 Detergent foam is disintegrated. Foam forming on the liquid surface is drawn down the draft tube into the highly turbulent and aerated zone of the rotor where it is destroyed.

8 Power consumption is no greater than that of conventional activated sludge plants . . . yet purification efficiency is equal to if not better than that of any type activated sludge installation.

9 Maintenance costs are low . . . the mechanism simple to service. The entire Cavitator unit can be removed for inspection without draining the tank.

For detailed information, ask for your copy of the newly published, 15-page booklet, " . . the CAVITATOR"

YEOMANS

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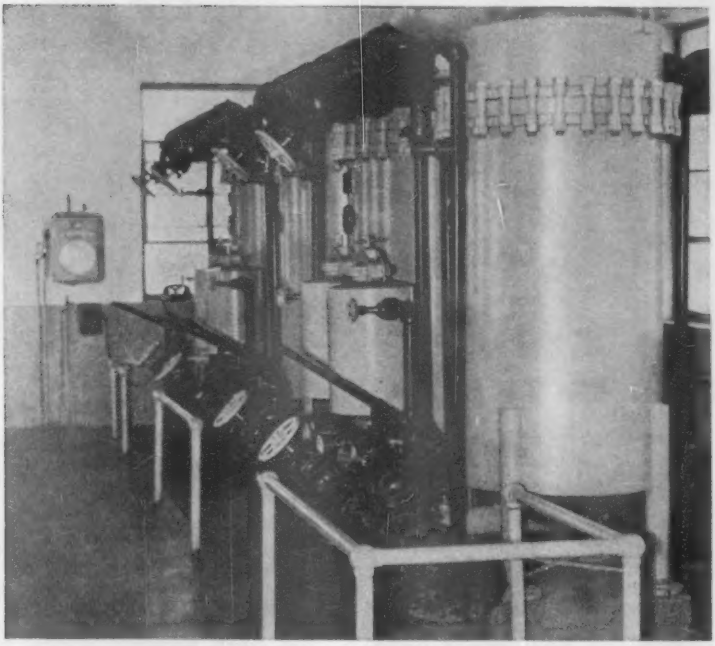
. . manufacturers of: distributors • clarifiers • digesters • mechanical aerators • pneumatic sewage ejectors • centrifugal pumps



PROPORTIONEERS INC. DIATOMITE FILTERS

at Tupper Lake, N. Y., which use . . .

ALOXITE® tubes for most efficient service

Water supply for the town of Tupper Lake, N. Y., is filtered by the diatomite filters shown above. Manufactured by Proportioneers Inc. of Providence, R. I., they use ALOXITE® aluminum oxide porous tubes as the support septa.

These filters have demonstrated that ALOXITE tube septa are highly economical, and give consistently satisfactory performance. The reasons for their superiority in diatomite filtering stem from many inherent advantages. For example, a high percentage of their total area is pore area. Pre-coat builds up evenly on their uniform structure. Backwash is effective and accomplished with a high degree of uniformity. ALOXITE septa alone will even give partially effective emergency filtration. And they resist acids, which permits cleaning of units clogged by iron and other materials.

Send for free 56 page booklet.

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Registered Trade Mark

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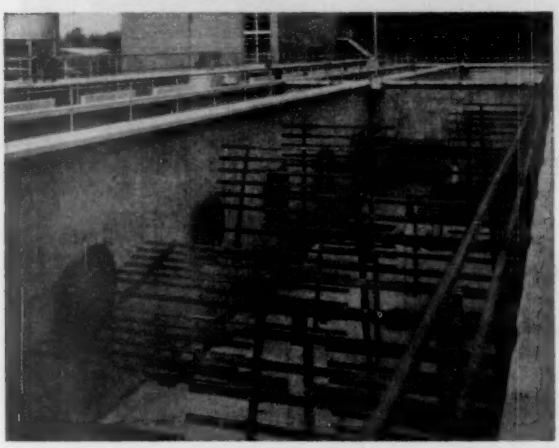
smaller basins possible / JEFFREY FLOCTROLS

minimize "short circuiting." They are designed with a combination of solid baffles with center ports, followed by rotating baffles attached to the shaft. FLOCTROLS hold water for longer detention periods than competitive designs. Smaller settling basins are possible because of this more efficient flocculation. Other important features: "tapering mixing" in multiple compartment arrangements . . . scientifically designed paddles for maximum number of "contacts." You can save on initial plant costs and reduce chemical usage with FLOCTROLS. For Catalog 833-A, write to Sanitation Sales Division, The Jeffrey Manufacturing Company, Columbus 16, Ohio.



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Bar and Disc Type Screens
Biofiltration Plant Equipment
Bucket Elevators
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Dry Chemical Feeders
FLOCTROLS
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Grit Collectors and Washers
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Screenings Grinders
Scum Removers
Sludge Collectors
Sludge Elevators
Traveling Water Screens

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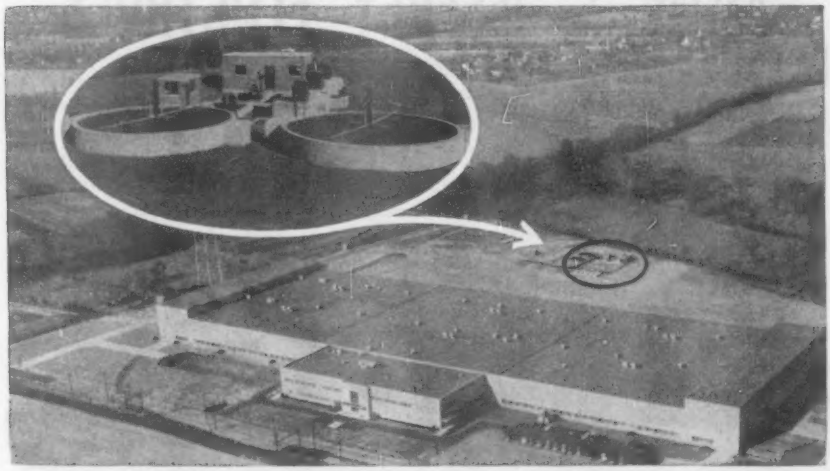
Link-Belt sewage treatment plant (inset) with PFT Rotary Distributors on 25' filter beds



Link-Belt chooses PFT Rotary Distributors for its own sewage treatment plant

As an important manufacturer of waste treatment equipment, the Link-Belt Company quite naturally drew upon its own fine equipment in adding sewage treatment facilities to its great modern plant in Colmar, Pa.

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The circular orifices in the Spreader Jets are always open to full size. This practical design effectively reduces clogging and simplifies maintenance.

Design of plant by / Link-Belt Company Engineering Dept.

Spreader Jets for the arms of PFT Rotary Distributor. Note various positions of the hinged deflectors which raise or lower to accommodate desired flow.

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SEWAGE AND INDUSTRIAL WASTES

Journal of the Federation of Sewage and Industrial Wastes Associations

Volume 28 **March, 1956** **Number 3**

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Sewage Works

TURNPIKE SEWAGE TREATMENT PLANTS *

By G. Gale Dixon and Herbert L. Kaufman

Respectively, Associate and Engineer, Parsons, Brinckerhoff, Hall & Macdonald New York, N. Y.

Toll roads are laid out with the purpose of avoiding towns; hence, service buildings required in the operation of these roads are usually not accessible to existing public water supply and sewerage systems. The combination restaurant and gasoline stations are located with reference to best serving the motoring public, without prime consideration of water supply or disposal of liquid wastes. As a result, the final effluent often must be disposed of by discharge into small water courses substantially dry in summer, and which occasionally are the source of a public water supply. Such conditions require a high degree of sewage treatment. This paper deals with sewage treatment installations on two important toll roads, namely, the Pennsylvania Turnpike and the Garden State Parkway.

Due to increased business, the Esso Standard Oil Co. in 1952 initiated a program of expansion of its restaurants and gasoline service stations on the original portion of the Pennsylvania Turnpike. The existing sewage treatment plants, built in 1941, consisted of separate batteries of multiple cylindrical concrete tanks 6 ft. in diameter. One battery functioned as a grease trap for kitchen wastes, and the other served as a septic tank for sanitary sewage. The effluents from the two batteries joined in a dosing chamber which discharged to sand filters. The performance of these treatment plants, despite their extreme simplicity, was completely unsatisfactory due to expensive maintenance caused by rapid clogging of the filters with grease, freezing in the winter and nuisance from odor and flies in the summer. More recent designs at similar service areas, employing settling tanks and intermittent sand filters dosed by rotary distributors, were as unsatisfactory in performance as the original installations, despite the fact that a high quality effluent is produced.

It was obvious that the character of the sewage, its flow pattern and the methods of treatment would differ in important respects from those of ordinary municipal sewage. The sewage is characteristically fresher and more concentrated than normal domestic sewage. It is composed almost entirely of human and kitchen wastes, with a higher than usual grease content. In addition the character of the sewage is influenced markedly by a relatively large proportion of synthetic detergent used in dishwashing.

Sewage Quantity

Direct measurements of sewage flow at the service area for any extended period were not available and impracticable to obtain. However, since most of the water used is returned almost immediately to the sanitary sewer, rec-

* Presented at 28th Annual Meeting, Federation of Sewage and Industrial Wastes Assns.; Atlantic City, N. J.; October 10–13, 1955.

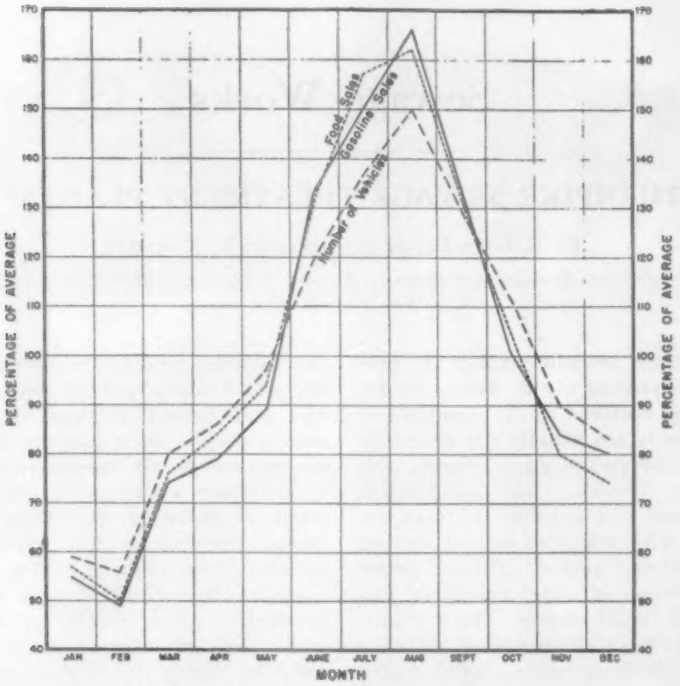


FIGURE 1.—Monthly variation in business on the Pennsylvania Turnpike for 1951.

ords of water use offered a satisfactory method of determining the basic flow pattern. Three of the Pennsylvania Turnpike service areas which were operating at maximum capacity in 1952 have metered water supplies. These metered records, covering the first nine months of that year, were invaluable in designing the new treatment plants.

The use of water varies with the volume of business on the turnpike. Figure 1 shows the variation in number of vehicles, gasoline sales and food sales, by months, for the year 1951 in terms of percentage of the average for the year. The number of vehicles is for the entire turnpike, while the sales refer only to the original portion served by Esso Standard Oil Company. The food and gasoline sales percentages agree closely with a peak of about 160 per cent of the average in August, and are reasonably representative of the monthly variation in water demand. It is interesting to note that the traffic pattern on the Pennsylvania Turnpike for other years is quite similar to that shown in Figure 1. The pattern on the New Jersey Turnpike also has the same characteristics, except that the peak is somewhat less when compared with the average.

To establish the pattern of short-term peaks, the water meters at the several service areas were read at 4-hr. intervals for two 7-day periods, which included the Fourth of July and Labor Day weekends in 1952. Figure 2 shows the maximum rates of water use during these weeks for various periods of time. The rates of sewage flow adopted for design, expressed in terms of counter seats were:

Average daily flow (g.p.d.)	350
Peak day flow (g.p.d.)	630
Extreme peak flow (g.p.d.)	1890
Minimum flow (g.p.d.)	0

The larger restaurants are equipped for table, as well as counter service. The turnover period for table service is about three-sevenths the turnover for counter service and the flows assumed per table seat are in that proportion.

Sewage Characteristics

Due to the separation of the kitchen and sanitary waste treatment facilities at the original Esso Standard Oil service areas, it was impractical to collect representative combined sewage samples. Accordingly, the raw sewage from the Brandywine and Bowmansville service areas operated by the Gulf Oil Company on the eastern extension of the Pennsylvania Turnpike, was collected and analyzed on August 13 and 14, 1952. Samples were taken every 30 min. during the 24-hr. period and composited in proportion to flow. Separate composites were made for the three 8-hr. periods and for the 24-hr. period. A second set of analyses was made by a private laboratory on raw sewage samples collected from October 3 to 12, 1953 at the Valley Forge service area of the Gulf Oil Company.

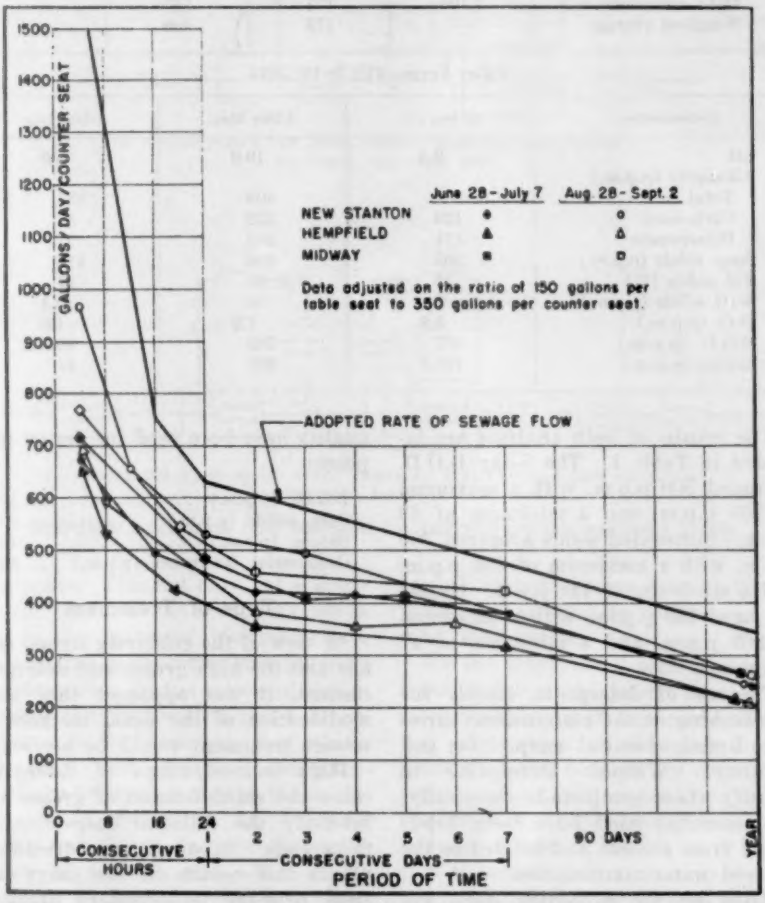


FIGURE 2.—Design rates of sewage flow for various periods of time based on metered use of water at Pennsylvania Turnpike service areas during 1952.

TABLE I.—Analysis of Raw Sewage from Service Areas on the Pennsylvania Turnpike

Sampling Period	Total Flow (gal.)	Susp. Solids (p.p.m.)	5-Day B.O.D. (p.p.m.)	Grease (p.p.m.)
Brandywine—Aug. 13–14, 1952				
8 AM– 4 PM	7,900	307	505	65
4 PM–12 PM	7,500	230	495	48
12 AM– 8 AM	4,300	135	531	108
24-hr. composite	19,700	191	518	—
Weighted average	—	240	508	—
Bowmansville—Aug. 14–15, 1952				
8 AM– 4 PM	3,300	205	569	78
4 PM–12 PM	2,700	187	532	83
12 AM– 8 AM	1,700	94	224	29
24-hr. composite	7,700	175	537	—
Weighted average	—	175	480	—

Valley Forge—Oct. 3–12, 1953

Determination	10-Day Av.	1-Day Max.	1-Day Min.
pH	9.5	10.0	9.0
Alkalinity (p.p.m.)			
Total	300	498	185
Carbonate	129	332	52
Bicarbonate	171	242	97
Susp. solids (p.p.m.)	305	496	118
Vol. solids (%)	91	96	87
Settl. solids (p.p.m.)	8.1	40	0.4
D.O. (p.p.m.)	5.8	7.2	4.6
B.O.D. (p.p.m.)	477	769	89
Grease (p.p.m.)	128.7	209	47

The results of both analyses are included in Table I. The 5-day B.O.D. averaged 500 p.p.m. with a maximum of 769 p.p.m. and a minimum of 89 p.p.m. Suspended solids averaged 300 p.p.m. with a maximum of 496 p.p.m. and a minimum of 118 p.p.m. Grease averaged 130 p.p.m., with a maximum of 209 p.p.m. and a minimum of 47 p.p.m.

The use of detergents, mainly for dishwashing at the restaurants, varies as to brand, chemical composition and quantity. Without attempting to identify these compounds chemically, the quantities used have been determined from records and related to the metered water consumption.

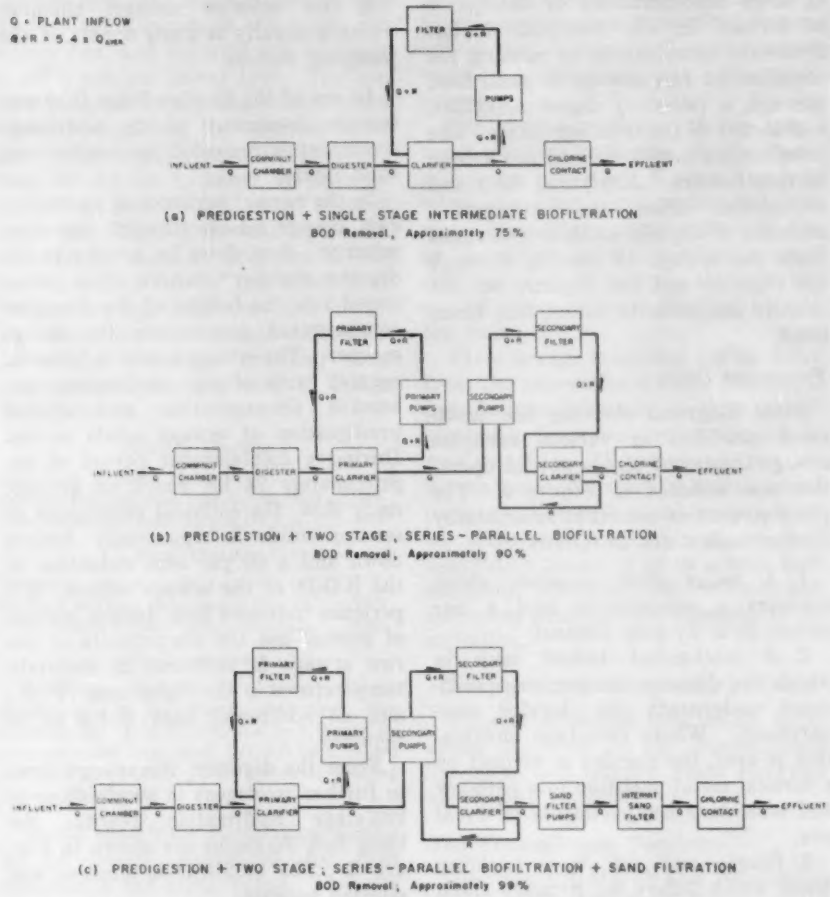
Based on the preceding data, the following assumptions as to sewage quality have been used for design purposes:

B.O.D. (p.p.m.)	500
Susp. solids (p.p.m.)	300
Grease (p.p.m.)	130
Commercial detergents (p.p.m.)	350

Type of Treatment

In view of the relatively strong sewage and the high grease and detergent content, it was apparent that some modification of the usual methods of sewage treatment would be necessary.

High concentrations of detergents cause the emulsification of grease and intensify the colloidal suspension in the sewage. In conventional treatment plants this results in the carry-over from primary to secondary units of grease and solids together with the



(a) PREDIGESTION + SINGLE STAGE INTERMEDIATE BIOFILTRATION
BOD Removal, Approximately 75%

(b) PREDIGESTION + TWO STAGE, SERIES-PARALLEL BIOFILTRATION
BOD Removal, Approximately 90%

(c) PREDIGESTION + TWO STAGE, SERIES-PARALLEL BIOFILTRATION + SAND FILTRATION
BOD Removal, Approximately 99%

FIGURE 3.—Typical flow diagrams for turnpike sewage treatment plants.

detergents. This not only has a detrimental effect on the secondary units, due to the increased biological load, but also due to characteristics inherent in detergents. In the activated sludge process, serious foaming has been attributed to the presence of synthetic detergents; and certain of the detergents are believed to retard the oxidation of the sewage by the activated sludge and also to decrease the settleability of aeration tank effluent. In standard or high-rate trickling filters detergents may inhibit the growth of aerobic bacteria. In sand filters the use of detergents has been followed within a short time by clogging of the sand with grease.

On the other hand, high concentrations of detergents do not cause a serious problem in the anaerobic digestion of sewage. A decrease in gas production will occur if the detergents replace considerable quantities of digestible and gas-producing soap compounds. However, the degree of digestion as measured by reduction of volatile matter during the process is about the same with or without detergents.

The tolerance of anaerobic digestion

to large concentrations of detergents is utilized in the turnpike sewage treatment installations by causing the comminuted raw sewage to pass, first, through a two-story digester-clarifier, and thence to the trickling filters. The installations here described are unique in this feature. Analytical data and observation show that substantial amounts of organic solids are removed from the sewage in passing through the digester and the digester effluent is more amenable to subsequent treatment.

Treatment Units

Flow diagrams showing the treatment provided at various turnpike sewage treatment plants now in operation are included in Figure 3. The plant structures consist of functionally similar basic units, as follows:

1. A comminutor chamber which contains a comminutor and a bar screen in a by-pass channel.
2. A mechanical Imhoff tank in which the digester compartment is located underneath the clarifier compartment. Where two-stage biofiltration is used, the clarifier is divided by a vertical metal partition into primary and secondary compartments of equal size.
3. Single and two-stage trickling filters which follow the primary clarifier. Where a two-stage trickling filter process is used, both filters are housed in a single structure. The rotating distributor is equipped with two pairs of arms, each pair receiving liquor from a different source. One pair of arms doses the outer annular ring of the filter which serves as the primary stage; the other pair doses the center circle which serves as the secondary stage. The primary and secondary filters are of equal area.
4. A control house and pumping station which contain recirculation pumps, chlorinators, flow measuring weir and other miscellaneous equipment.
5. The chlorine contact chamber which generally is made a part of the pumping station.

In one of the Garden State Parkway sewage treatment plants additional treatment is provided by intermittent sand filters.

In the normal sequence of operation, raw sewage passes through the comminutor; then, flows by gravity to the digester-clarifier * where it is introduced into the bottom of the digestion compartment just above the sludge scraper. The sewage comes in intimate contact with sludge undergoing anaerobic decomposition and partial predigestion of sewage solids occurs. During a displacement period of approximately 24 hr. based on average daily flow, the colloidal suspension of sewage solids is apparently broken down and a 40 per cent reduction in the B.O.D. of the sewage occurs. Experience indicates that during periods of normal use the temperature of the raw sewage is sufficient to maintain temperatures in the digester of 70° F., and no additional heat seems to be required.

From the digester, the sewage flows to further treatment in single-stage or two-stage biofiltration plants; the basic flow diagrams are shown in Figure 3. The biofiltration process was selected because:

1. A high degree of treatment could be obtained.
2. Fresh, aerated liquor from the filters is continuously returned to the clarifiers so that these units are kept fresh and free from septic action and odors during periods of low flow.
3. There is a relative freedom from filter fly nuisances.

Basis of Design

The single-stage intermediate treatment plant is designed for a 2-hr. detention period in the clarifier, based on

* "Clarigester" equipment manufactured by Dorr-Oliver, Inc.

average flow plus recirculation liquor. Surface settling rate is 425 g.p.d. per square foot, and the weir overflow rate is 400 g.p.d. per linear foot. The biofilter is dosed by a pump with a rated capacity equal to the extreme peak flow. This results in a recirculation ratio of 4.4 to 1, based on average daily flow; and 2.0 to 1, based on peak daily flow. Hydraulic loading on the filter is 26 m.g.a.d., and the B.O.D. loading equals 2.1 lb. per cubic yard for the average daily flow and 3.3 lb. per cubic yard for the peak daily flow.

For the two-stage trickling filter treatment plants, the basis of design is as follows:

Primary Clarifier

Detention period * (hr.)	1.5
Surface settling rate (g.p.d./ sq. ft.)	850
Weir overflow rate (g.p.d./ft.)	800

Final Clarifier

Detention period † (hr.)	1.7
Surface settling rate (g.p.d./sq. ft.)	720
Weir overflow rate (g.p.d./ft.)	800

Trickling Filter

Each stage is dosed by a pump with capacity equal to the extreme peak flow. The recirculation ratio is: (a) 4.4 to 1, based on average daily flow; and (b) 2.0 to 1, based on peak daily flow. The hydraulic loading equals 27 m.g.a.d.

In the sand filter installation, dosing is by pump, controlled by float switches in the pump sump. The rate of filtration based on average daily flow is 470,000 g.p.d. per acre, in accordance with usual state practice.

Chlorine is applied to the treatment plant effluent with hypochlorinators. The digested sludge is removed from the plant by scavenger service. Because of the small size of the treatment plants, multiple treatment units are considered impractical. Hence, by-pass arrangements as flexible as possible are provided. The comminutor, digester or any other structure, can be by-passed without affecting operation of the remaining units. Standby pumping equipment is provided to permit pump repairs and maintenance without disrupting the treatment process.

The hydraulic design of the treatment plants is such that, in the event of pump failure during periods when the plants are unattended, the water level in the pump wells will rise and overflow to the chlorine contact chamber and then pass through the outfall sewer without flooding any of the units.

These sewage treatment plants differ from the conventional small municipal installations primarily in that several treatment functions are performed in each structure. The nature of the service conforms to a more or less standard pattern. The equipment incorporated in these treatment plants is well adapted by reason of compactness, high efficiency, minimum maintenance and operating demands, and economy of installation.

Description of Completed Projects

General considerations which influenced the work on the Pennsylvania Turnpike and Garden State Parkway are briefly outlined.

The Pennsylvania Turnpike

Between Pittsburgh and Harrisburg the Pennsylvania Turnpike is served by 9 service areas. The four eastern service areas required sewage treatment plants. The number of counter seats at each of the service areas and the design average daily sewage flow are:

Service Area	Counter Seats	Flow (g.p.d.)
Plainfield	53	20,000
Blue Mountain	77	30,000
Path Valley	77	30,000
Cove Valley	53	20,000

The five service areas to the west of these are located where municipal sewerage is available for the disposal of the wastes.

* Based on average flow plus recirculation liquor.

† Based on a constant recirculation flow.

The service areas are located to the side of the highway—the Blue Mountain and Cove Valley service areas serving only westbound traffic, and the Path Valley and Plainfield service areas serving only the eastbound traffic. The area available for the service stations is quite limited and generally the sewage treatment plant is located within a few hundred feet of the restaurant.

Effluent from the Plainfield, Blue Mountain and Cove Valley sewage treatment plants discharges into very small streams, where it frequently constitutes the major part of the flow. There is no stream available to receive effluent from the Path Valley plant and it is disposed of through subsurface tile fields. Treatment provided at all plants consists of digestion-clarification, followed by two-stage series-parallel biofiltration and chlorination.

Figure 4 shows the Path Valley treatment plant as seen from the edge of the service station parking area. To the right is the digester-clarifier; in the center, the pumping station and control house; and to the left, the trickling filter. The photograph was taken prior to landscaping and fencing. Both the digester-clarifier and the filter are provided with wooden covers, principally to conserve heat and prevent freezing in the structures during long periods of extreme cold.

FIGURE 4.—Path Valley sewage treatment plant, Pennsylvania Turnpike.

The Garden State Parkway

Six restaurants have been constructed and a seventh is now under construction along the Garden State Parkway. Two of these, located north of the Raritan River, discharge into municipal sewers; the remaining five required the construction of sewage treatment plants. The number of counter and table seats at each of the service areas and the design average daily sewage flow are:

Service Area	Counter Seats	Table Seats	Flow (g.p.d.)
Cheesequake	48	131	40,000
Manasquan	24	92	30,000
Forked River	48	131	40,000
Absecon	24	92	30,000
Seavillo	24	92	30,000

South of the Raritan River the north and southbound lanes of the parkway are divided by a broad planted strip usually about 400 ft. wide. All service areas are located in this median strip as are the sewage treatment plants, with the exception of the Cheesequake service area. There is ample area available and the treatment plants are located 600 ft. or more from the restaurants. They are usually easily accessible from the restaurant; yet at an ample distance so that they can be easily screened. The sites are large enough to readily accommodate future expansion and the various structures are compactly grouped; yet allow generous working space.

Effluents from the Cheesequake, Forked River and Manasquan sewage treatment plants discharge into either small streams or streams used for recreational purposes. The treatment provided is similar to the methods used on the Pennsylvania Turnpike. Effluent from the Absecon plant discharges into the storm drainage system of the parkway, and additional treatment by intermittent sand filters is provided. Effluent from the Seaville facilities flows in a drainage course about 3,500 ft. through a salt marsh to Ludlam's

FIGURE 5.—Garden State Parkway, Cheesequake sewage treatment plant.

Bay at a point approximately one-half mile from leased oyster lots. The ample dilution available makes it feasible to provide a lesser degree of treatment, consisting of digestion-clarification, single-stage, intermediate biofiltration and post chlorination.

Figure 5 shows the Cheesequake sewage treatment plant prior to landscaping. The parkway in this location is on a considerable side slope. The two-stage biofilter is shown in the lower right, and in the center is the pump station and control house. The primary and secondary recirculation pump wells are to the right of this structure and the chlorine contact chamber is just to the left. The units are not covered since the winters are relatively mild. To the right of the control house is located the diversion manhole provided to simplify splitting the sewage flow should the treatment plant require enlargement when restaurant facilities are increased.

Treatment Plant Operation

The engineering services performed in connection with the sewage treatment plants have included placing the facilities in service, training operating personnel and furnishing a simple operating manual with instructions on sampling and simple testing. This service is believed to be essential for clients whose principal concern is catering to the comforts and needs of the traveling public. A full-time operator or attendant is not employed at any of the service area treatment plants.

Laboratory checks on the performance of several of the treatment plants were made soon after completion by composite sampling of the midday flows at frequent intervals. Analytical results for the Path Valley and Cove Valley sewage treatment plants on the Pennsylvania Turnpike in June, 1954, and for the Manasquan plant on the Garden State Parkway in August, 1955, were similar. With a B.O.D. of 200 to 230 p.p.m. in the raw sewage, all three treatment plants delivered an effluent with only 14 to 19 p.p.m. B.O.D. The B.O.D. reduction in the predigester stage ranged from 38 to 60 per cent.

In order to evaluate sewage treatment plant performance after one year of operation, a joint test was conducted for a week at the Path Valley treatment plant on the Pennsylvania Turnpike. The results are given in Table II. Samples were collected hourly, from 8:00 AM June 29 to 4:00 PM July 6, 1955, and composited in 8-hr. periods. In general, the plant was op-

TABLE II.—Summary of Laboratory Analysis,[1] Path Valley Plant, Pennsylvania Turnpike

Date (1955)	Flow (g.p.m.)	B.O.D. (p.p.m.)			Suspended Solids (p.p.m.)	
		Raw Sewage	Predigestion Effluent	Final Clar. Effluent	Raw Sewage	Final Clar. Effluent
June						
29	8.9	162	94	8	88	8
30	10.6	216	113	23	130	28
July						
1	14.6	212	132	25	106	26
2	12.7	308	171	20	83	12
3	13.4	271	151	24	131	50
4	10.1	262	164	19	201	74
5	12.8	333	192	36	194	28
6	4.6	275	163	18	144	41
Av.	11.7	261	151	22	134	33

[1] Made on composite samples taken hourly, from 8:00 AM, June 29 to 4:00 PM, July 6, 1955.

erating at from 50 to 70 per cent of design capacity.

The B.O.D. of the raw sewage varied from a maximum daily average of 333 p.p.m. to a minimum daily average of 162 p.p.m. Corresponding values for the predigestion effluent varied from a maximum of 192 p.p.m. to a minimum of 94 p.p.m. The values for the individual days showed a rather consistent reduction of about 40 per cent. The B.O.D. of the final clarifier effluent, prior to chlorination, varied from a maximum daily average of 36 p.p.m. to a minimum of 8 p.p.m. The minimum daily reduction in B.O.D. was 88 per cent and the maximum 95 per cent, with an average of 92 per cent.

The reduction in suspended solids showed less consistent results, varying from a maximum of 86 per cent to a minimum of 62 per cent, based on average daily values. The final effluent was clear and odorless at all times. The treatment plant was doing a good job while only requiring part-time attention from operating personnel.

Due to faulty fabrication of the filter distributor, the unit was operating as a single-stage filter, although the design provided for two-stage filtration. This condition is now being corrected and a series of tests will be run to obtain a direct comparison of single-stage and two-stage operations for equal filter loading and practically identical applied sewage characteristics.

Acknowledgment

The authors gratefully acknowledge the assistance of Esso Standard Oil Company, who granted permission to perform the tests of June 29 through July 6, 1955, at their Path Valley sewage treatment plant; Dorr-Oliver Company, who provided the laboratory equipment and a chemist to assist in performing these tests; and Wellington Donaldson for suggestions and constructive criticism.

CHROMATOGRAPHIC DETERMINATION OF VOLATILE ACIDS

By H. F. Mueller, A. M. Buswell,* and T. E. Larson †

Respectively, Research Assistant, Chief, and Chemistry Subdivision Head, Illinois State Water Survey Division, Urbana, Ill.

The importance accorded the control of volatile acids in the anaerobic digestion of both domestic and industrial wastes is well known. The method of direct distillation for the determination of volatile acids has been widely used for control purposes in sewage treatment plants. This method is empirical and its accuracy is limited by the hydrolysis of complex compounds with mineral acid, and by variable percentage recovery of each of the volatile acids. These objectionable features have led to the suggestion of steam distillation (1)(2)(3). This technique reduces the possibility of hydrolysis and provides 92 to 98 per cent recovery of the volatile acids. However, the length of time required and the large volume of distillate often necessary for complete recovery of the acids is undesirable.

Chromatography

Recently numerous studies have pointed to the usefulness of chromatographic separation and identification of organic acids from various sources (4)(5)(6)(7)(8). The principle on which chromatography depends is well known and has been described in the earlier colloid literature as selective adsorption.

In the investigation reported here, organic acids are adsorbed on silicic acid from an aqueous solution and subsequently eluted by solutions (eluting agents) of varying concentrations of butyl alcohol in chloroform. The eluting agents force the organic acids to pass through the chromatographic column in such a manner that they are selectively adsorbed and separated into bands of almost pure substances. The collection of fractions permits the identification and quantitative determination of the substances present. Several of these methods employing silicic acid as the adsorbent have proved satisfactory for the fractionation of organic acids from both simple and complex mixtures.

This report specifically concerns an application of the method of Bulen *et al.* (7). The chromatographic column length and solvent system are modified so that members of the lower volatile acids may be completely separated and identified using a solvent system of increasing polarity, or may be completely recovered using a single eluting agent. Recovery studies on mixtures of these commonly occurring acids have indicated the potentialities of this technique for a more accurate and rapid determination of volatile acidity in the control of sludge digestion.

Determination of Volatile Acidity

The chromatographic column is prepared in essentially the same manner as described by Bulen *et al.* (7). Five grams of silicic acid,‡ washed free of fines, are thoroughly mixed with 3.5 ml. of 0.5 N. sulfuric acid and added to 30 ml. of chloroform, previously equilibrated against 0.5 N. sulfuric acid. The resulting slurry is transferred to the chromatographic tube

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‡ Mallinckrodt's silicic acid (100 Mesh) specially prepared for chromotography.

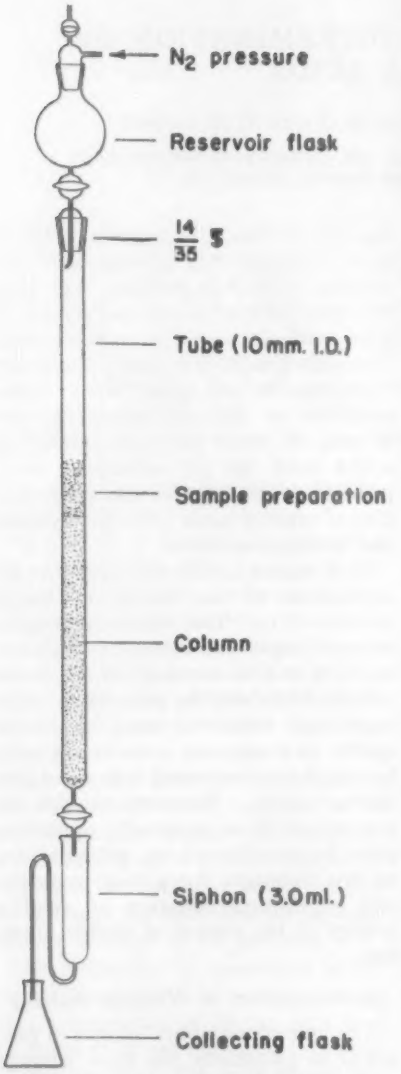

FIGURE 1.—The chromatographic column and related apparatus.

(Figure 1) having a glass wool plug to support the column. The stop cock is opened and a slight gas pressure of nitrogen or air at 10 to 12 cm. of mercury is used to pack the column and hasten the removal of the excess chloroform. Approximately 3 cm. of chloroform is retained above the column to ensure thorough wetting of the sample to be added.

The digester liquor sample, clarified by centrifuging and acidified to a pH value of approximately 2, is thoroughly mixed with two grams of silicic acid, and the preparation is quantitatively added to the top of the column. The sample container is rinsed with 1.0 ml. of chloroform which in turn is used to wash down any particles of the sample preparation adhering to the inside of the tube. A glass wool plug is forced down firmly on the surface of the sample preparation in the column using a glass rod. This packing action thoroughly wets the sample with the chloroform retained above the initial column preparation.

The chromatographic column now may be used for either the separation and identification of individual organic acids, or for the determination of the total volatile acidity attributed to butyric, propionic and acetic acids. The technique differs only in the eluting systems used.

Separation of Volatile Acids

The individual volatile acids may be separated and identified by the addition of several solvent systems, each of increasing polarity. The solvent systems are equilibrated against 0.5 N. sulfuric acid and passed through dry filter paper prior to use. The selected solvent schedule for the separation of the acids from the sludge consists of successive applications of 40 ml. of chloroform, 75 ml. of 2 per cent, 40 ml. of 5 per cent, and 75 ml. of 15 per cent n-butanol in chloroform. The solvents are added to the top of the column through the reservoir shown in Figure 1 and are forced to travel through the column under a gas pressure (nitrogen or air) of 10 to 12 cm. of mercury which is applied to the top of the reservoir. This pressure is maintained throughout the elution of the acids. Each subsequent solvent is added as

the previous solvent just enters the glass wool capping. The applied pressure provides a flow rate of approximately 3.0 ml. per minute. Using an intermittent siphon, fractions 3.0 ml. in volume are collected. To each fraction an equal volume of ethanol and one drop of 0.1 per cent phenol red indicator is added. The mixture is titrated with 0.02 N. sodium hydroxide to an end-point color which remains stable for 30 sec. The use of a magnetic stirrer insures contact between the two phases.

A determination is made on a blank from each of the solvent systems and these values are subtracted from the respective effluent titration values. The volume held up in the column (approximately 14.0 ml.) is compensated for by subtracting each new blank value from the fifth 3 ml. fraction subsequent to the addition of each solvent system.

Each acid has a characteristic peak effluent volume which is that fraction having the highest titration value. This volume is determined by the column dimensions and solvent systems employed, and is independent of the concentration of the acids present within the range of the column. These values can be determined for each acid using known acids of high purity, both singly and in mixtures. The method permits the detection of amounts as small as 0.0025 milliequivalents of the individual acids, however, this column is best suited for separations of the volatile acids in the range of 0.5 to 5.0 mg. of each acid (calculated as acetic acid).

Figure 2 illustrates the separations of the organic acid mixture by the technique described. The titration values clearly show the peak effluent volumes and the order of elution of the individual acids. Table I shows recovery data on mixtures of the lower volatile acids with the method described. The accuracy is seen to be exceedingly good.

The recovery of formic acid is not quantitative if fumaric or glutaric acids are present. These acids eluted with formic acid, may be separated if desired, by the use of a longer column and the solvent changes suggested by Bulen *et al* (7). Lactic and succinic

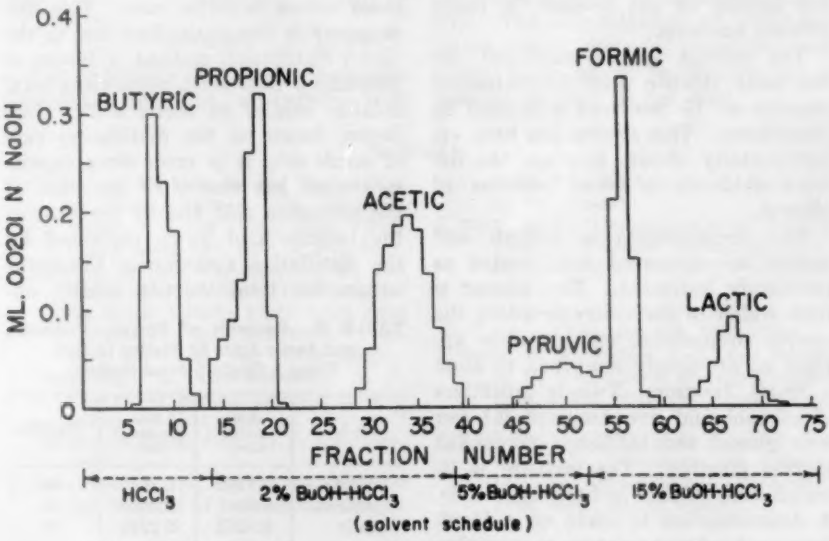

FIGURE 2.—The chromatographic separation of organic acid mixtures.

TABLE I.—Recovery Data on Individual Volatile Acids Separated from Mixtures

Acid	Acid Added[1] (meq.)	Acid Recovered[1] (meq.)	Recovery (%)
Butyric	0.0173	0.0171	99
	0.0140	0.0133	95
	0.0140	0.0141	101
Propionic	0.0204	0.0199	98
	0.0163	0.0158	97
	0.0163	0.0170	104
Acetic	0.0263	0.0271	103
	0.0383	0.0390	102
	0.0763	0.0785	102

[1] Calculated as milliequivalents.

acids also require a second treatment for complete separation.

Determination of Total Volatile Acids

In digestion control the procedure is quite simple for the determination of the total volatile acidity due to butyric, propionic and acetic acids, but it is limited to samples where interfering acids are known to be absent. Tests by the authors revealed that organic acids, such as pyruvic, lactic, etc., which would interfere usually do not appear or are present in insignificant amounts.

The solvent system employed for the total volatile acid determination consists of 15 per cent n-butanol in chloroform. This system has been experimentally shown to elute the desired acids in a 30-ml. volume of effluent.

The chromatographic column and sample are prepared and treated as previously indicated. The solvent is then added to the reservoir above the sample preparation and pressure applied as previously described to elute a 30 ml. fraction. Twenty milliliters of ethanol and five drops of 0.1 per cent phenol red indicator are added to this fraction. The mixture is titrated with 0.02 N. sodium hydroxide. A determination is made on a blank from each solvent mixture preparation and this value is subtracted from the titration value. The total volatile acidity is calculated as acetic acid. Table II shows recovery data on known mixtures of the pure volatile acids present in a 30-ml. volume of effluent.

Technique Application

The application of the techniques described is further illustrated by the comparative data in Table III. These data were obtained on samples of overflow liquor from two anaerobic digesters, one treating wastes from an industrial yeast plant, and the other, wastes of domestic origin. The samples were clarified by centrifugation prior to use (time and speed not controlled). Qualitative analysis indicated the presence of only butyric, propionic and acetic acids. Pyruvic, formic, lactic and succinic acids were not present in either sample.

As can be seen from the results tabulated for each sample, fairly close agreement for total volatile acidity was obtained by the two chromatographic procedures described. However, the values obtained for the total volatile acidity by the direct distillation method are not consistent with these values in either case. This discrepancy is due to the fact that in the direct distillation method, a factor of 100/62.5 is used when calculating total volatile acidity as acetic acid. This factor, based on the distillation rate of acetic acid is in error since experimentation has shown 89 per cent of the propionic acid and 97 per cent of the butyric acid to be recovered by the distillation technique. Corrected values for total volatile acidity ob-

TABLE II.—Recovery of Butyric, Propionic, and Acetic Acids by Elution in Toto Using a Single Solvent System

Acid	Acid Added[1] (meq.)	Acid Recovered[1] (meq.)	Recovery (%)
Butyric	0.1282	0.1252	98
Propionic	0.0641	0.0625	98
Acetic	0.1282	0.1242	97

[1] Calculated as milliequivalents.

TABLE III.—Volatile Acidity of Sewage Effluent Samples as Determined by Direct Distillation and Chromatographic Procedures

Sample	Distillation		Chromatographic Separation				Chromatographic Elution in Toto
	Total[1]	Total[1] (Corrected)	C-4	C-3	C-2	Total[1]	Total[1]
Industrial waste	1,891	1,640	227	496	991	1,548	1,808
	1,673	1,423	223	529	1,075	1,656	1,734
	1,689	1,439					1,772
	1,703	1,453					
	1,927	1,677	225	512	1,033	1,602	1,610
	1,815	1,560					
Domestic[2] waste	6,221	4,920	1,423	1,869	2,890	5,377	5,104
	6,161	4,860	1,481	1,960	3,147	5,632	5,495
	6,080	4,779					
			1,452	1,914	3,018	5,504	

[1] Calculated as acetic acid.
[2] Sample from sour digester.

tained by the distillation method, as determined by the ratio of the acids separated by the multiple solvent technique, appproach the values obtained by the chromatographic techniques.

Even the poorest checks (Line 1, Table III) are within the interpretative limits for treatment plant operation.

Summary

The suitability of a chromatographic technique for the separation and identification of volatile acids was tested on pure compounds as well as on samples of domestic and industrial origin. Comparative data on total volatile acidity determinations with the direct distillation method, commonly used for control purposes, indicate the potential use of this technique for the controlled loading of anaerobic digesters. The determination of metabolic intermediates, butyric, propionic and acetic acids offers possibilities as a research method in this field.

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HIGH-RATE TRICKLING FILTERS IN GERMANY *

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The most widely used measurement of trickling filter efficiency is the B.O.D., the biochemical oxygen demand. But the B.O.D. value is only a statistical value, as there are millions of bacteria, protozoa and other microorganisms which feed upon sewage and sludge solids. It is not known how much oxygen each of these little organisms requires to consume a specific amount of solids—only the total amount of oxygen consumed by all of them can be measured. It is quite possible that the relation between the quantity of oxygen required and the quantity of solids consumed is different in a filter film or activated sludge, as one contains mostly bacteria and the other contains mostly protozoa; thus their efficiency in consuming oxygen may be different.

If, for instance, raw sewage has a B.O.D. of 180 p.p.m. and settled sewage a B.O.D. of 120 p.p.m., and if it is intended to produce an effluent having a B.O.D. of 20, then 100 p.p.m. B.O.D. must be removed in biological treatment. This means that 100 mg. of oxygen must be applied per liter of sewage, if the B.O.D. value really measures the amount of oxygen required for treatment.

Earlier Studies

In the United States some excellent studies have been published by Weston and Eckenfelder (1) and others on the oxygen demand of cell material synthesis and cell material oxidation. They report an oxygen demand of 80 per cent of the B.O.D. value to be removed. This result relates to complete biochemical treatment. In practice, however, complete treatment often is not required; but more or less of the B.O.D. may be removed by flocculation and settling. This process is more economical than full biological treatment. The difference between a high-rate biological filter and a low-rate filter may be explained by operation of combined flocculation and biological treatment in a high-rate process, and of full biological treatment in a low-rate process.

According to Weston and Eckenfelder 80 mg. of oxygen is required per liter of sewage if full biological treatment and 100 p.p.m. B.O.D. reduction are desired. For a high-rate process using flocculation as well as biological treatment the amount of oxygen required is less; the amount of oxygen required may be 70 mg. or even only 50 mg. Nevertheless, the latter requirement is five times the amount of oxygen which may be dissolved in sewage. It is well known that the maximum solubility of oxygen in water is about 10 p.p.m. Therefore, if the necessary amount of oxygen is to be applied by dissolving it in sewage or recirculated effluent, recirculation of four or five times is required.

Filter Aeration

There are three ways of applying oxygen: (a) by introduction from the surface, (b) by aeration through a perforated bottom and natural or artificial draft within a filter, and (c) by solution in crude or recirculated sewage. For the reasons mentioned, designers in Germany do not rely on the oxygen

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brought to the filter by solution in sewage, but provide for direct aeration of a biological filter as the most effective way of applying oxygen.

Aeration introduced from the surface is not considered sufficient, as most high-rate trickling filters in Germany are often 10 or 12 ft. deep. This depth permits treatment of rather strong settled sewage (one having a B.O.D. of 200 p.p.m.) in a single-stage filter without recirculation. In many European countries sewage is stronger than in the United States. The B.O.D. of raw sewage may vary between 250 and 350 p.p.m., and of settled sewage between 150 and 250 p.p.m. Only in Switzerland is the water consumption high, and sewage rather weak. In Germany, a tendency to higher water consumption and, therefore, to weaker sewage was observed in many towns during recent years.

Installations for American military camps treat a weak sewage. Figure 1 illustrates a trickling filter which receives sewage from both an American and a German village. Crude sewage is pumped to a rectangular settling tank, flows to the trickling filter and then to a circular humus tank. The trickling filter is nearly 12 ft. deep and has a false bottom; water outlet and aeration holes are provided in the wall below the false bottom. The wall of the filter is somewhat higher than the level of the distributor arms, in order to protect the applied sewage against wind and freezing. In addition, the higher the wall, the better the upward draft through the trickling filter. Recirculation is not provided. The surface load on this filter is 20 m.g.a.d., a high rating. The average of many measurements of crude sewage indicated an applied B.O.D. of 157 p.p.m., and an effluent B.O.D. of 14 p.p.m.; a 91 per cent reduction. For a high-rate filter this is a rather good result It proves that with a filter of 12 ft. depth full treatment can be achieved without recirculation.

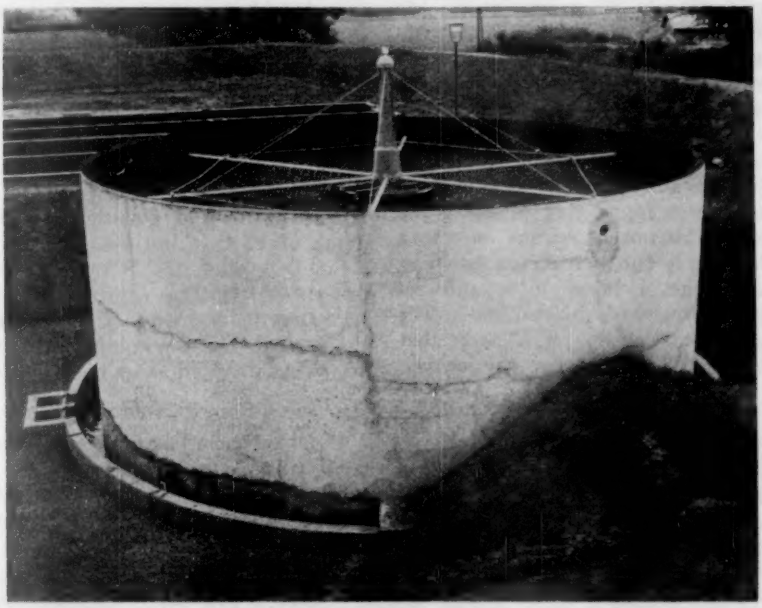

FIGURE 1.—Deep trickling filter near Frankfort Airport. Note aeration openings in base.

Recirculation

In Germany high rate trickling filters generally operate without recirculation. If the effluent is recirculated, only a recirculation ratio of perhaps 0.3 is employed. Recirculation ratios of 1, 2 or higher are not used for domestic sewage. In the opinion of the author recirculation should be regarded mainly as a means of bringing microorganisms, ferments, etc. into the applied sewage, and—on account of its oxygen content—to freshen raw sewage which is in danger of becoming septic (this may also be done by preaeration before settling). Recirculation may be used for regulating the surface dosing rate, but this can also be done by varying the filter depth. There are some types of industrial wastes which cannot be successfully treated without recirculation.

Deep filters and shallow filters using recirculation may accomplish the same results. Deep filters may mean high pumping costs. When shallow filters are used, and a certain percentage of filter effluent is recirculated, the pumping costs correspond to the volume of settled and recirculated sewage pumped. The necessary pumping pressure is determined by the height of the filters, the head loss in the settling tanks, the pumping sump and friction head. Considering all these facts, it was found that pumping the incoming volume of sewage once to a high filter is not more expensive than pumping to a lower filter and repumping some of the volume. The special situation of each treatment plant must be taken into consideration.

Filter Loading Equation

Strong sewage requires deep filters, as can be proved by the filter loading equation. Since surface area times height is equal to the volume of the filter, the value of the B.O.D. applied may be divided by the filter volume. The following B.O.D. filter loading equation is finally obtained:

$$\text{B.O.D. loading} \times \text{height} = \text{Surface dosing rate} \times \text{B.O.D.} \times 8.33 \quad (1)$$

The B.O.D. loading is given in pounds of B.O.D. per acre foot per day (p.a.f.d.); the height in feet; the surface loading rate in million gallons per acre per day (m.g.a.d.); the B.O.D. in parts per million (p.p.m.), and the final term 8.33 is the dimension equivalent between parts per million and pounds per million gallons.

While in low-rate filters sludge is nearly completely mineralized within the filter, in high-rate filters sludge must be washed out of the filter into the humus tank. Therefore, a minimum surface loading rate is necessary. Acording to Imhoff (2) this minimum loading rate is: 0.8 cu. m. per square meter per hour equals 0.85 million gallons per acre per hour (m.g.a.h.) It is not necessary to apply this dosing rate throughout 24 hr., but only during the hours of day time peak flow. Assuming that the average hourly quantity at the time of peak flow is determined by dividing the daily quantity by 18 hr., 0.85 m.g.a.h. correspond to 15 m.g.a.d.

If, for example, the B.O.D. of settled sewage is 200 p.p.m., and a B.O.D. loading of 2,000 p.a.f.d. is allowed, then from Eq. 1:

$$2{,}000 \times 12.5 = 15 \times 200 \times 8.33$$

According to the equation, a filter depth of 12 ft. 6 in. is necessary. If a B.O.D. loading of 2,500 p.a.f.d. is to be applied, the filter depth must be 10 ft. Thus the surface dosing rate and the loading can be regulated by the filter depth as well as by recirculation.

Filter Calculations

If filter dimensions are to be calculated, or the treatment results are to be found by considering filter dimensions, loading, strength of sewage, etc., it seems better to calculate the B.O.D. value of the final effluent instead of the filter efficiency. If, for instance, a B.O.D. of 200 p.p.m. is to be reduced

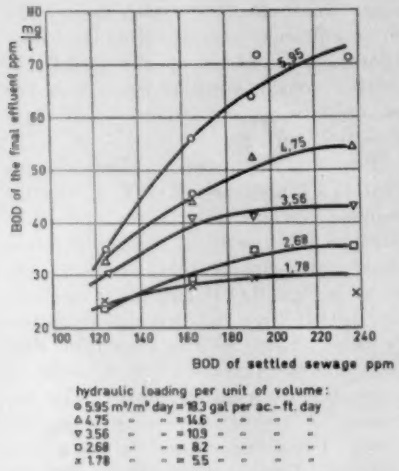
BOD of the final effluent ppm
mg/l
80
70
60
50
40
30
20
100 120 140 160 180 200 220 240
BOD of settled sewage ppm
5.95
4.75
3.56
2.68
1.78
hydraulic loading per unit of volume:
○ 5.95 m³/m³ day = 183 gal per ac.-ft. day
△ 4.75 " " = 146 " " " "
▽ 3.56 " " = 109 " " " "
□ 2.68 " " = 82 " " " "
× 1.78 " " = 55 " " " "

FIGURE 2.—Filter loading *vs.* final effluent (data from Southgate, 1950).

to a B.O.D. of 20 p.p.m., the filter efficiency is given by a ratio of 180 to 200. The ratio term 180 may be calculated with a tolerance of ± 10 per cent, then the final effluent will be:

$$200 - 198 = 2$$

or $$200 - 162 = 38$$

Thus, the variation is between 2 and 38, which means that the accuracy is not sufficient; although a tolerance of ± 10 per cent is not very great with filter calculation.

If an attempt is made to calculate the B.O.D. of a final effluent by means of measurements and statistical methods, and a tolerance of ± 25 per cent is conceded, the desired final effluent B.O.D. of 20 p.p.m. then varies between 16 and 25 p.p.m. A tolerance of ± 25 per cent seems necessary, as there are so many influences on filter calculations which cannot be considered exactly and as it is not possible to measure the B.O.D. with a greater accuracy.

Southgate and the British Water Pollution Research Board (3) have investigated the influence of the B.O.D. of settled sewage and of the hydraulic loading of the filter on the final effluent. Figure 2 shows their results. The B.O.D. of the final effluent increases with increasing B.O.D. of settled sewage and with increasing hydraulic loading. Multiplying the hydraulic loading by the B.O.D. value

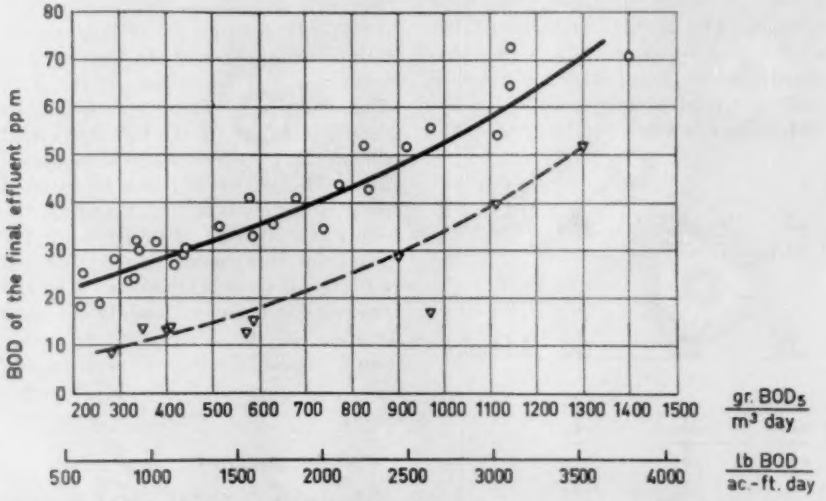

FIGURE 3.—Comparison of filter loading and final effluent B.O.D. values. Lower curve illustrates results with thoroughly aerated German filters of more recent design. Upper curve includes American, English and older German results.

of the settled sewage gives the B.O.D. loading in pounds per acre foot per day. The author has plotted the B.O.D. of the final effluent versus the B.O.D. loading and found that the results of Southgate's experiments are situated nearly on one line, as indicated by the upper curve in Figure 3. Several American (4)(5)(6) and German operating results are also included. The trend of these data is illustrated by the heavy line, with a tolerance of ± 25 per cent as previously discussed.

In the reports on these experiments, occasional ponding of the filters is mentioned; thus indicating that the whole filter volume is not always used, and that aeration is not quite sufficient. The majority of the filters studied were filled with rather small media, smaller than is used today.

The results of modern German filters (7)(8)(9), which the author knows are thoroughly aerated and free from ponding, are indicated in Figure 3. Mostly these filters have 1½-to 3-in. media and are rather deep. The trend of these points is illustrated by a broken line parallel to the upper curve.

This graph indicates that strong sewage is easier to treat than weak sewage. The B.O.D. loading of 2,000 p.a.f.d. may be obtained by a small hydraulic loading and strong sewage, as well as by greater hydraulic loading and weaker sewage. In both cases the same final effluent is obtained. The filter efficiency and the B.O.D. reduction in percentage of the B.O.D. of settled sewage must be greater in the case of strong sewage and smaller hydraulic loading.

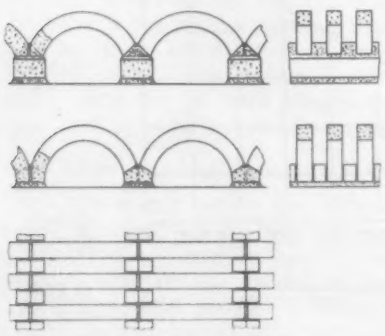

FIGURE 4.—Prefabricated patented concrete arches for filter bottoms.

Practical experience demonstrates that the higher the B.O.D. of the incoming sewage, the better the filter works. The results of roughing filters show quite clearly that where an extremely high B.O.D. loading is applied, the B.O.D. can be diminished rather quickly. Some points shown in Figure 3 are the average of 10, 20, or even more B.O.D. measurements. The influence of temperature is not considered. These curves are valid for the moderate European climate or similar climates elsewhere, but definitely not for the semi-tropics or for areas having a warm climate throughout the year. They are valid, for high-rate filters having thorough aeration and sufficient rinsing; for example, a minimum dosing rate of 15 m.g.a.d.

High-rate and low-rate filters are to be distinguished only by the surface loading rate and not by the B.O.D. loading per unit of filter volume. High-rate filters can function with a low B.O.D. loading as well as with a high loading. The B.O.D. loading may be determined according to the final effluent desired. The lower the points plotted in Figure 3, the better the final effluent, and the better the filter operation. The closer a point is situated towards the right side of Figure 3, the higher the B.O.D. loading and the lower the investment costs. The superiority of treatment indicated by the lower curve is caused mainly by good aeration of the filters and by their depth. Good aeration is very important and depends on several influences.

Filter Design Considerations

The design of prefabricated concrete arches for filter bottoms is illustrated in Figure 4. The arches may be laid

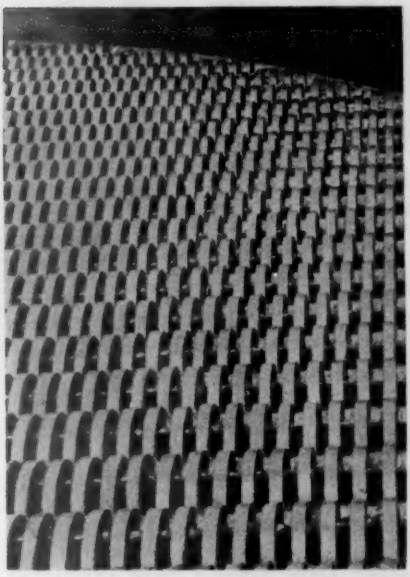

FIGURE 5.—Filter floor installation using prefabricated arches.

on concrete ribs or directly on the floor. As the distance between the arches is the same as their width, there is about 40 per cent free space between them. A filter floor made of these concrete arches is illustrated in Figure 5.

Filters having a prefabricated filter floor and large aeration holes at the end of the aeration channels beneath the concrete floor are in use (Figure 6). The aeration holes may be shut in winter to prevent excessive cooling. The treatment plant illustrated is located at a military camp installation near Stuttgart.

In addition to a suitable filter floor and aeration channels, uniformity of the filter media is most essential for thorough aeration. Equal size of the media is more important than the absolute diameter, although too small media increases the danger of blocking and ponding. In general, the range of diameters of the media should be not more than 1 to 2; for example, 1½-in. to 3-in. The space between the large media will be filled by the smaller media if uniformity is lacking.

Uniformity of filter media provides not only the largest free volume between the individual particles and, therefore, the best aeration and least

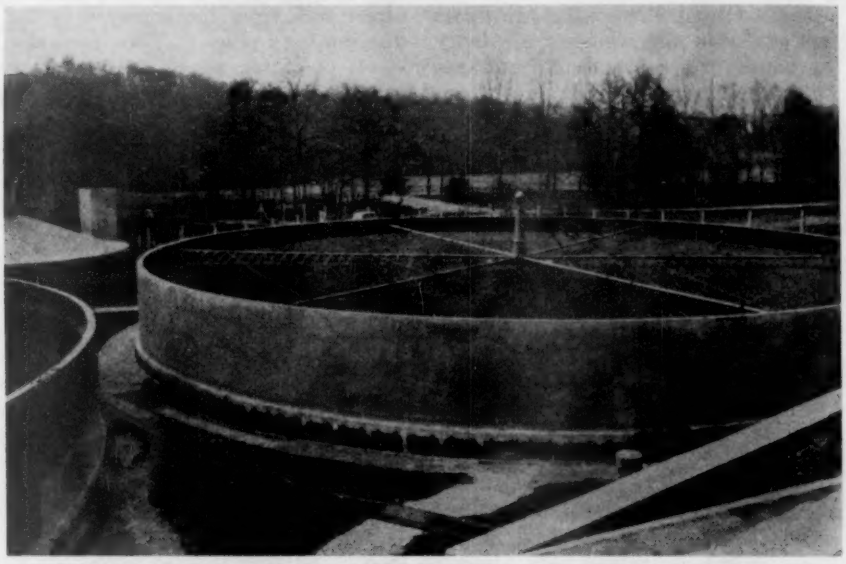

FIGURE 6.—Large aeration openings are provided below the floor of these filters.

danger of ponding; it also provides the longest detention period according to the equation:

$$\text{Sewage vel.} = \frac{\text{volume per second}}{\text{free horizontal area}}$$

The rate of liquid flow must be higher the smaller the free area between the grains. If all the free volume is filled up, the filter must pond in order to build up an additional liquid weight to press the liquid through the small free area.

Various measurements of the detention period by radioisotopes have shown that, on the average, sewage remains in the filter about 30 min. The detention period depends on the depth of the filter, the free volume in the filling, and the hydraulic loading per unit of surface area. Measuring the detention period with radioisotopes is a good means for controlling the free volume between the grains of the filter medium and the work of the filter.

Sufficient aeration of a filter may always be obtained by natural draft. Artificial ventilation is not necessary as has been demonstrated by the experiments of Wuhrmann (10) and others. Closed filters with ventilators are advisable only in close proximity to houses, to prevent the nuisance caused by filter flies. Well aerated and well operated high-rate filters do not have objectionable odors.

Sprinkler Devices

The thing to be observed is an equal distribution of sewage. Only circular filters having rotary sprinklers have been constructed in Germany during recent years. A sprinkler having a 24-in. entrance pipe and a 124-ft. diameter is shown on the test stand in Figure 7. The test stand was erected to measure the head loss for varying outputs of the sprinkler and distribution of water on the area of the filter. Shallow tanks of exactly 1 sq. meter were installed and connected with a measuring tank.

Actual measurements with these tanks revealed that it is rather difficult to calculate liquid distribution in advance. Measurements on the test stand often differed from theoretical calculations, because of the influence the Law of Bernoulli and of centrifugal force.

The head loss versus the discharge rate of sprinklers is plotted in Figure 8. The steep curve relates to sprinklers having 16-in. entrance pipe and direct flow from the entrance to the distributing pipes. The sprinkler starts operating at 10 cm. or ⅓ ft. head loss, and with a flow of 20 gal.

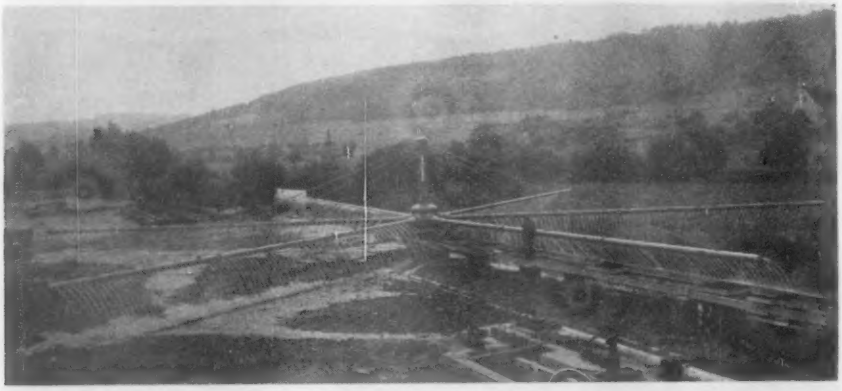

FIGURE 7.—A 124-ft. diameter sprinkler on test stand (this has 24-in. entrance pipe).

per second. The greater the discharge, the higher the pressure or head loss required. At 5 ft. head loss, 80 gal. per second are discharged. The head loss of the pipe line from the feeding tank to the sprinkler is included in the values plotted in this diagram.

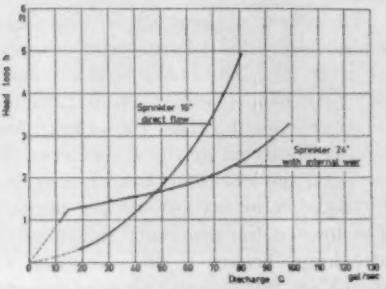

FIGURE 8.—Characteristic curves of sprinklers.

The lower curve is the characteristic curve of a sprinkler having a 24-in. entrance pipe. The sprinkler feeds small quantities of sewage to only two distributing pipes, the other pipes being blocked by an internal weir. When the quantity is increasing, and correspondingly the necessary pressure, sewage flows over the internal weir to the next pair of pipes and finally to the last pair—if there is a total of six pipes. This sprinkler delivers up to 100 gal. per second with somewhat more than a 3 ft. head loss. Characteristic curves of sprinklers may be determined for all sprinkler types in the same manner as for pumps.

It is well known that a good distribution of sewage can be obtained by splash plates attached to the distribution pipes. Splash plates promote oxygenation of the sewage as it falls from the sprinkler to the filter surface. The author is not convinced that this improves the filter efficiency much, because of preference for a thorough aeration of the filter itself. Splash plates have the advantage that larger outlet holes can be made in the sprinkler arms, and thus the danger of blocking the outlet holes is reduced.

There has been discussion, during recent years, of whether it would be preferable to limit the revolving speed of sprinklers in order to increase the intervals between two water sprays. Feeding siphons for sprinklers are in general use, especially for low-rate filters, partly to increase the quantity of water sent to the sprinkler and partly to make the filter operate intermittently. Experience shows that feeding siphons and low-rate filters operate best with about 5 min. of dosing time and 5 min. as an interval between the dosing periods. The interval may also be obtained by allowing the sprinkler to revolve very slowly, for instance at a rate of 20 min. for one revolution of a four-arm sprinkler. Experiments of this kind have been made in England and Germany. A sprinkler of this type must be mechanically driven, if the same interval for various loads is to be maintained.

Microorganisms may prefer to get their food not continuously, but in periodical doses, as do human beings, with the difference that their optimum periods are much shorter than for man. This enormous number of microorganisms may take their food in alternating shifts, or it may be that a certain rhythm of feeding for the whole lot of organisms is desirable. Experience with siphon feeding and slowly revolving sprinklers suggests the conclusion that periodical feeding is preferable, at least with low-rate filters. The author does not consider there is any difference if the periodicity is regulated by slowly revolving sprinklers or by siphons. In the intervals between feeding periods the trickling filter is filled with air; this assists its functioning.

In the sewage treatment plant at the Frankfort airport, shown in Figure 1, the high-rate filter was fed periodically as the pumps were operated by float switches. As the treatment results of this filter were good, it may be supposed that periodical dosing may

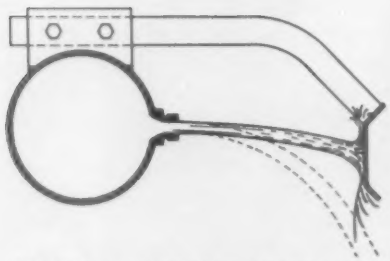

FIGURE 9.—Sprinkler designed with braking plate.

also be applied to high-rate filters. For this reason sprinkler speed regulation was examined on the test stand. It seemed to be advisable to let the sprinkler start with as little head loss as possible and without any braking system, but to apply brakes at higher speed.

Design of a braking plate located some distance from the sewage outlet is illustrated in Figure 9. Small quantities of sewage flow down and do not touch the braking plate, but large quantities discharging under higher pressure are broken by the plate. Operation of this type is shown in Figures 10 and 11. The sprinkler is to be seen (Figure 10) on the test stand just at the moment when the liquid jet touches the brake, and in Figure 11 the sprinkler is working at full capacity with the liquid being splashed by the brake.

The effect of braking is well illustrated by the characteristic curve (Figure 12). The heavy lines are characteristic of a sprinkler without brakes. The curve on the right shows head loss versus discharge of the sprinklers; the curve on the left shows head loss versus the number of revolutions per minute. The broken lines indicate the effect of attaching brakes. The number of sprinkler revolutions remains nearly constant from the moment the water touches the braking plate. Certainly, braking means loss of energy. Therefore, the broken line show the head loss to be higher for the same output of the sprinkler.

In an effort to reduce this head loss, the design drawn in Figure 13 was

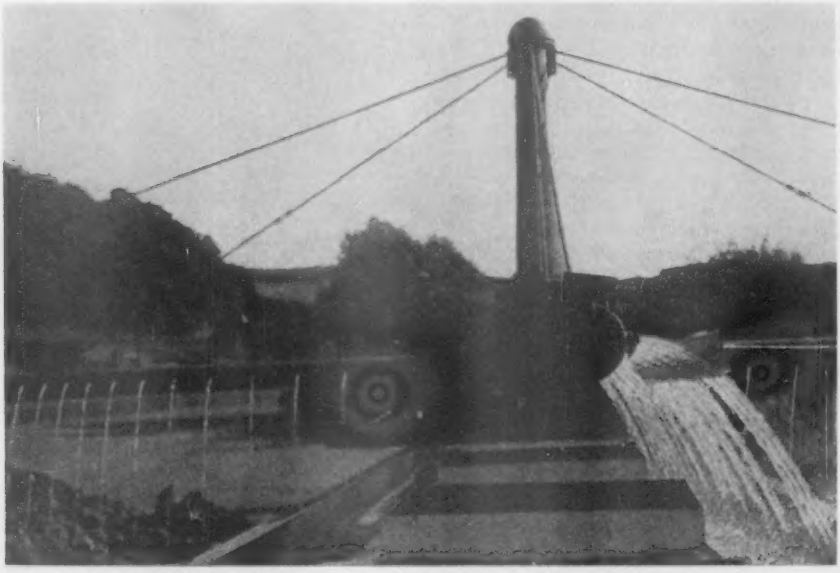

FIGURE 10.—Low-rate operation of sprinkler using brake.

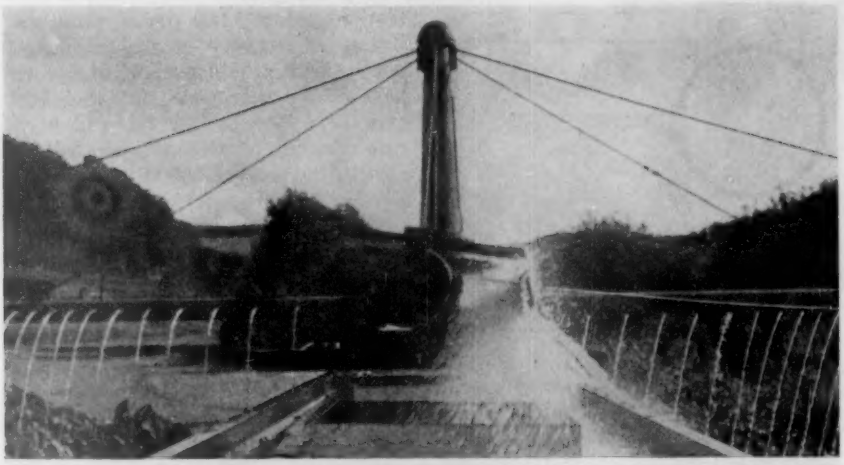

FIGURE 11.—High-rate operation of sprinkler using brake.

chosen. When this type operates at full scale, the liquid jet is thrown against a braking plate similar to a Pelton turbine. The same reaction force is obtained with this braking plate, but with reduced head loss. By measuring on the test stand, it is possible to design a sprinkler for the characteristic curves required for each installation.

Combined Pump and Sprinkler

By means of the characteristic curves, Figure 14 shows how a sprinkler cooperates with the sewage pump. Often pumps are installed between the settling tank and the trickling filters, so that the sprinkler is fed by a pump. Curve 1 is the characteristic curve of a pump; pressure head (h) versus dis-

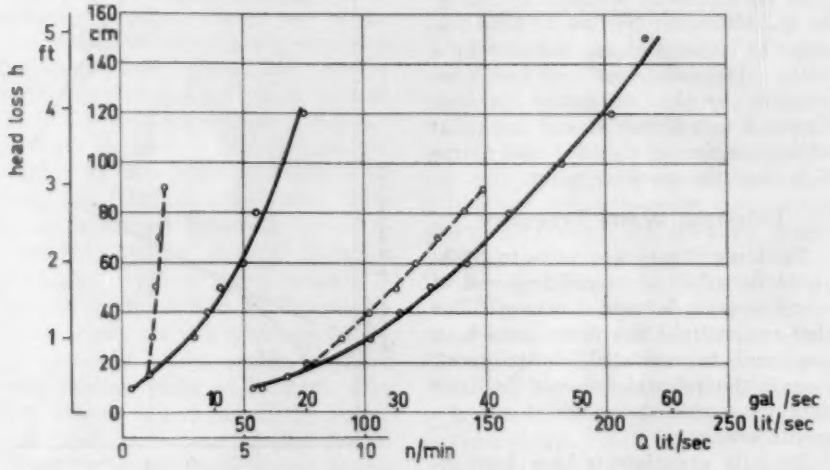

FIGURE 12.—Characteristic curves of sprinkler discharge: heavy lines, without brakes; broken lines, with brakes.

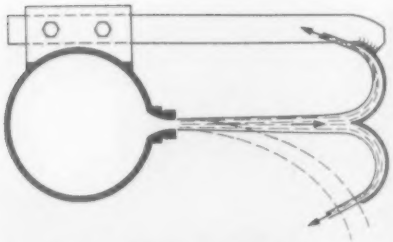

FIGURE 13.—Design of sprinkler braking plate having less head loss.

charge (Q). Curve 2 indicates the geometrical height between pump and sprinkler. Curve 3 represents the friction or head loss in the feeding line. The difference between Curves 3 and 4, is the head loss of the sprinkler itself. The point of intersection of the characteristic line Curve 1 and Curve 4 is the working point for both pump and sprinkler; the total pressure head (h) required and the discharge (Q_1) are given by this point. From the horsepower curve (N) and from the pump efficiency curve (η) the required horsepower and the efficiency of the pump can be found. It is advisable to choose the working point in such a way that η comes near to its optimum.

If the discharge is changed from Q_1 to Q_2, additional friction or head loss must be introduced, for instance by a valve. The additional head loss is indicated by the difference between Curve 5 and Curve 4, and the point of intersection of Curve 1 and Curve 5 is then the working point.

Industrial Waste Treatment

Trickling filters are able to withstand the effect of overloading and of many organic industrial wastes. For that reason, trickling filters have been preferred to activated sludge treatment in the industrial area of the Ruhr with its combined industrial and domestic sewage.

Recently experiments have been directed to the treatment of wastes containing phenols, especially in concentrations below 1,000 p.p.m. In these instances, recovery of the phenols is not economical and phenols, therefore, have to be destroyed. In laboratory experiments of the Ruhrverband, high-rate trickling filters have operated efficiently in removing 80 to 90 per cent of the phenols. A small-scale pilot plant is operating and a full-scale pilot plant is now under construction. Phenol wastes may be treated up to a concentration of about 80 p.p.m. Higher concentrations must be reduced by dilution or recirculation.

Trickling filters are used for dairy waste treatment, but not as high-rate filters. Two procedures have worked satisfactorily: (a) partial treatment by combined chemical and biological process, and (b) full treatment by alternating double filtration. In the first process, developed by Jung and Preuss (11), a comparatively small amount of iron and ferrous sulfate is added to

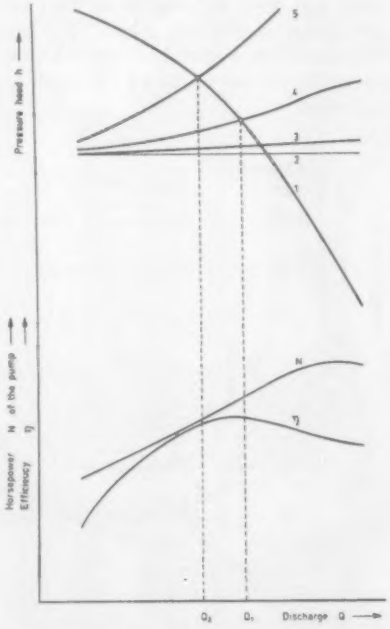

FIGURE 14.—Characteristic curves of pump and sprinkler combinations.

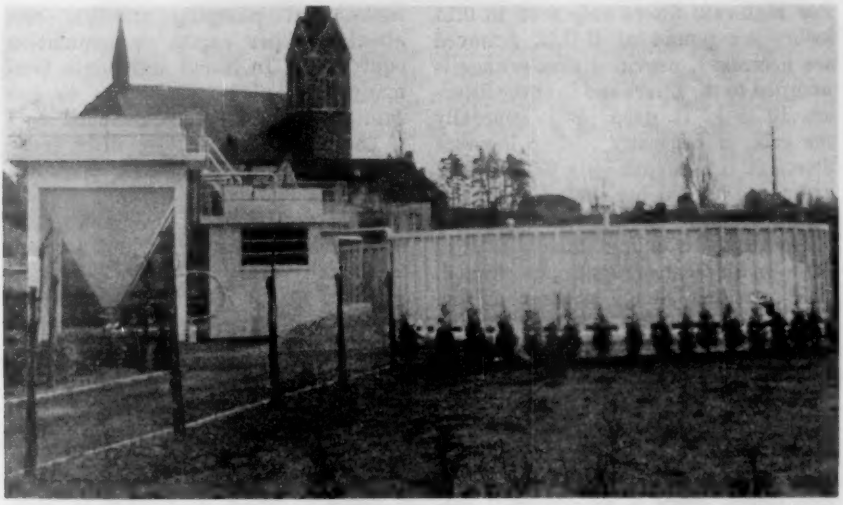

FIGURE 15.—Alternating double filtration plant treating dairy wastes, Belgium.

the sewage before entering the filter. The filter is thus provided with a thin biological film containing iron, which is able to treat this organic waste and to reduce the B.O.D. to 80 or 100 p.p.m. The filter operates with a high recirculation rate.

Alternating double filtration consists of two trickling filters working in series, with the point of application normally changed every two weeks. The first-stage filter then operates as the second-stage filter, and receives partly treated sewage which reduces the thickness of the biological film and prevents clogging. This process, developed by Southgate in England 20 years ago (12)(13), has been made use of in several European countries.

An alternating double filtration plant for treating dairy wastes in Belgium is illustrated in Figure 15. On the right are two trickling filters; the pumping house, center, contains small feeding tanks on its roof. The filter effluent is pumped to the humus tanks, left, and part of the settled effluent is recirculated to the filters. With a charge of 700 p.a.f.d. the B.O.D. is reduced from 1,860 to 13 p.p.m. on the average. Treating butter wastes is more difficult than treating milk wastes or cheese factory wastes containing whey. With milk or cheese wastes the alternating double filtration plant may be loaded as high as 1,100 p.a.f.d. and, nevertheless, the B.O.D. of the final effluent will be about 15 p.p.m. or less.

Costs of Sprinkling Filters

Finally, something should be said about costs, as these vary greatly with regard to the special situation of each treatment plant. Comparing the operating costs of high-rate trickling filters with the activated sludge process, it is found that it is much cheaper to pump sewage on the trickling filter than to compress air and blow it into the water. The reason is principally that 79 per cent nitrogen must be compressed together with the 21 per cent of oxygen introduced into the sewage. Secondly, the efficiency of oxygenation is not as high as the efficiency of a modern pump.

In Europe, for modern activated sludge plants, 0.27 to 0.36 kwhr. are required per pound of B.O.D. removed.

For high-rate filters only 0.09 to 0.14 kwhr. per pound of B.O.D. removed are necessary, provided that sewage is pumped to the filters and that the filters are 10 to 12 ft. deep (as is generally the case in Germany). For low-rate filters of 6 ft. depth only 0.05 to 0.09 kwhr. are needed per pound of B.O.D. removed.

High-rate trickling filters require little maintenance and supervision. The activated sludge process, on the other hand, allows a higher B.O.D. loading; therefore, it needs less area and has a comparatively lower investment cost. It also is capable of providing full treatment in large sewage works.

As to the investment costs of high-rate filters, there is an apparent difference between the mainly industrial area of the Ruhr (with high prices for land and difficult civil engineering conditions, on account of the coal mines and the ground water situation) and other parts of Germany (which have a less crowded population and a more favorable situation for a sewage treatment plant). In the industrial area complete treatment plants, providing primary sedimentation, sludge digestion, high-rate trickling filters, humus tanks, and pumping stations, cost about $10 per capita or population equivalent. In North and South Germany these plants cost $6 to $8 per capita or population equivalent.

The high-rate trickling filter plant at Salzgitter near Hanover is shown in Figure 16. This includes a circular settling tank in the foreground, two high-rate trickling filters and a circular humus tank in the background. The raw sewage is pumped and sludge is digested. The complete treatment plant cost $7 per capita or population equivalent, and it reduces the B.O.D. by 95 per cent. As far as is known, there is no other sewage treatment plant in Europe where such a good result is obtained at such a low cost.

There is much discussion in Germany as in other countries, as to whether the activated sludge process or the high-rate trickling filters should be used. Apart from large works of 20 m.g.d. or more, only a general answer to this question can be given, as it depends on the special situation of each town or industrial firm requiring sewage treatment. In many instances high-rate trickling filters can provide adequate treatment at a reasonable price.

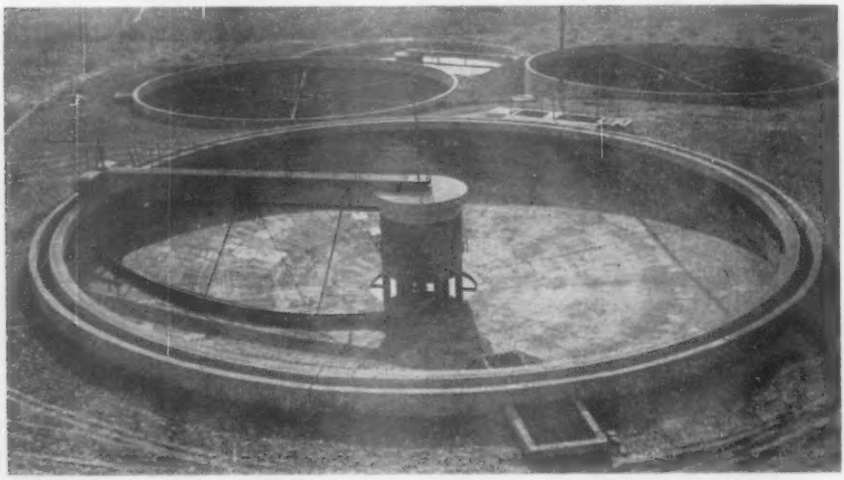

FIGURE 16.—High-rate trickling filter plant at Salzgitter, Germany.

Author's Note—The per capita costs given are based on the official rate of exchange ($1.00 equals D-Mark 4.20). Based on subsequent experience during my 1955 visit in the United States, it is believed that the purchasing value of $1.00 corresponds on the average to one-half of the official rate of exchange. This means that an investment cost of D-Mark 25 per capita is not equal to $6.00, but $12.00, when compared to the purchasing value of the dollar. Certainly there are differences in the prices for professional services, equipment, materials, wages, etc., and it is somewhat difficult to judge the purchasing value of the two currencies. However, the costs given, as based on the official rate of exchange, are too low. Accordingly, they may be approximately doubled if the purchasing value of the D-Mark and the dollar are to be compared.

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SEWAGE DISPOSAL AND WASTE TREATMENT IN CANADA *

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In a discussion of sewage and industrial waste treatment on the national level in Canada, the crux of the problem lies in the words "on the national level." Much has been accomplished by the Canadian Government in connection with domestic sewage disposal, but there is not a clear pattern in relation to industrial wastes. During the periods between wars there is little government-controlled industrial production while during wars there is a rapid increase in manufacturing plants which produce military supplies. These facilities are frequently controlled to some degree directly by the government or its crown corporations. The question of waste treatment, then, is often secondary concern because of the urgent need for production.

The accomplishments in sewage treatment at the national level by the various government departments and agencies during the past 25 years can be reviewed with some degree of satisfaction. While there has been no uniform national policy regarding sewage treatment, similar approaches to the problem have been made by most of the departments having a direct interest in it. The general attitude has been that treatment of domestic sewage will be undertaken when the need is known or demonstrated. There are, as a result, very few instances where at least primary treatment with chlorination of the effluent has not been provided.

One of the fundamental problems is the absence of any direct control by any one authority such as is found normally in the legislation of the province or state. Each Federal department is free to decide what shall be done, subject within reason to the wishes of the province in which the problem is located, and also to some degree to the wishes of other government departments which have either direct or indirect interests.

Canadian Legislation

Because legislation plays such an important part in pollution control a brief review is presented of acts and regulations at the national level which have a bearing on waste disposal. At the international level there is the Boundary Waters Treaty of 1909 which is concerned, in part, with the quality of boundary waters between Canada and the United States. It requires that "the waters herein defined as boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other." Either country may refer questions to the International Joint Commission for investigation which is followed by a report including conclusions and recommendations. The Boundary Waters Treaty does not confer authority on the Commission to deal directly with sources of pollution. However, the Commission has been able to use its influence effectively in having remedial action taken. Basically the authority and responsibility for correcting transboundary pollution origi-

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nating in Canada rests with the province in which the pollution originates.

The Navigable Waters Protection Act places restrictions on the discharge of materials of certain kinds into navigable waters or waters flowing into navigable waters. Its purpose is to protect the interests of navigation and it is concerned chiefly with those types of wastes which would tend to obstruct channels and streams. The Fisheries Act is similar in character and places restrictions on the discharge of materials deleterious to fish life.

The Migratory Birds Convention Act prohibits the deposit or discharge of "oil, oil wastes or deleterious substances . . . in any water frequented by migratory wildfowl, or that flows into such water, nor on ice over either of such waters."

The Department of National Health and Welfare Act states that the Minister of National Health and Welfare shall enforce "any rules or regulations made by the International Joint Commission, promulgated pursuant to the treaty . . . so far as they relate to health." The treaty referred to is the Boundary Waters Treaty of 1909.

The Criminal Code of Canada defines a common nuisance as "an unlawful act or omission to discharge a legal duty, which act endangers lives, safety, health, property or comfort of the public, or by which the public are obstructed in the exercise or enjoyment of any right common to all Her Majesty's subjects." This has not been regarded in the past as a useful means of effecting pollution control. It is difficult to prove the cause and locate the source of a common nuisance when wastes are involved.

Some thought has been given in recent sessions of the Canadian Parliament to a possible revision of the Criminal Code of Canada to strengthen the pollution control features of the law. Opinions have been expressed that the Criminal Code is not a suitable vehicle for such legislation. If it is thought desirable that the Federal Government should have a measure of control over pollution affecting more than one province or boundary waters, then some law other than the Criminal Code may be required.

The Department of Transport has "General and Special Regulations for the Government of Public Harbours in Canada," which place restrictions on the discharge of various wastes, rubbish and oil. The National Harbours Board Regulations are similar and are based on the Canada Shipping Act.

There is no Federal legislation in Canada which can be used effectively in achieving pollution abatement in relation to the discharge of municipal sewage and industrial wastes. As previously noted regulations are basically the responsibility of the province in which the wastes originate.

Department of National Health and Welfare

Because of its responsibility in matters related to health, and the intimate relationship between pollution and water-borne disease, the Department of National Health and Welfare has always been concerned with the problem of waste treatment on Federal property. While the act creating the department does not confer any specific authority in this field beyond that already quoted, a program of cooperation with other departments has been developed.

As a result of this cooperation the Public Health Engineering Division of the department usually has an opportunity to review waste treatment problems and submit recommendations in regard to the degree of treatment. In numerous cases the Division has prepared plans and specifications. In other instances, where consulting firms or the engineers of another department have carried out the design, the Division usually has an op-

portunity to review the plans and specifications and submit comments. This cooperation with other Federal Departments has improved over the years and at the same time a closer liaison has been developed with the engineers in the Provincial Health Departments. This of course has been helpful in achieving results which are acceptable to all control authorities, and should eventually result in more uniform compliance with acceptable standards of waste treatment.

Until fairly recently the only Federal department employing engineers with special training in sanitation and public health has been the Department of National Health and Welfare. At present it is the only Federal department with a Public Health (Sanitary) Engineering Division.

Types of Treatment

In the first waste treatment plants on Federal property the emphasis was on types of treatment which required a minimum of attention. As a result, it is not surprising that septic tanks were frequently used. One of the earliest of these was built at an army camp in the Province of Quebec. It was designed to serve a population of 5,000 and is still in service but will be replaced shortly as it is now serving about 10,000 persons. Another large septic tank installation is located at an army camp in Ontario. Consideration has been given to its replacement on a number of occasions but in the meantime it has given excellent service.

A number of Imhoff tanks were designed and constructed during the period 1939–45 in locations where a better type of treatment was required. When adequate attention and control has been provided these units have given good results. Failing proper control they can be a source of nuisance, but this is true of any sewage treatment plant. With emphasis being placed on the conservation of manpower and metals, many sewage treatment plants were constructed during the early 1940's which combined primary sedimentation, usually septic tanks, with trickling filters and chlorination. Stationary distribution devices constructed of wood were used in the trickling filters.

While it is generally recognized that septic tank effluents are not well suited for further treatment by trickling filters or chlorination, good results were obtained in most instances. Some of these treatment plants are still in operation. Also during this same period a number of small mechanized treatment plants, such as "clarigesters" were built. At least one of these used a tile disposal bed for secondary treatment, while in others secondary treatment was provided by trickling filters.

With a return to more normal conditions following World War II, many sites such as munition storage depots and Air Force training camps were abandoned. Those that were continued in use frequently had reduced personnel, which adversely affected the operation of some treatment plants. This has resulted in major changes in operation and in some cases to changes in the treatment process.

The trend during this period has been towards complete treatment. Biofiltration and activated sludge type facilities are most frequently adopted and some use has been made of sewage lagoons. It is too early to determine whether greater use will be made of lagoons but, where conditions favor their use, the low cost and simplicity of operation may result in their adoption. This development has been centered in Western Canada following earlier use in North Dakota and adjacent states. A sewage lagoon will be installed in an army camp in Ontario in 1956 and will afford an opportunity to evaluate this treatment method under climatic conditions in Eastern Canada. In this instance it

will serve as secondary treatment for septic tank effluent.

Operation

One of the major problems of waste treatment is related to plant operation. Even with the simplest types of treatment process it is frequently difficult to secure personnel who have a genuine interest in maintaining the treatment plant in good operating condition and in producing satisfactory results. The problem is even more difficult where skilled attention is required. While operators can be assisted with their problems by engineers who have special training and experience in this field, the limited engineering staff of both Federal and provincial health departments makes it exceedingly difficult to maintain adequate supervision. With the present keen competition for engineering services, it is becoming increasingly difficult for health departments, both Federal and provincial, to maintain a qualified staff of engineers.

The Department of National Defense, which maintains the majority of Federal sewage treatment plants, has taken steps to raise the standard of operation by means of a training course for operating personnel. Eventually this should be reflected in greatly improved results. Some of the provinces have given treatment plant operators an opportunity to acquire a better understanding of the principles of operation and of the tests and analyses which will help them to control results or to locate the source of troubles which may develop. It is apparent that greater emphasis will need to be placed on the training of operators in the future. The training courses, for the present at least, are of such short duration and limited scope that there will be a continued need to provide professional assistance to the operator in solving his difficulties. There is no doubt that the success of any sewage treatment plant depends on careful operation, and the development of training courses is most encouraging.

There are, in Canada, nearly 250 municipal sewage treatment plants serving a population of approximately three million people, which is almost one-fifth of the total population. This includes municipalities of 1,000 population or over. More than one-third of the wastes receive only primary treatment and, judging by the age of many of the treatment plants and giving consideration to recent increases in population, there is little doubt that many of them are overloaded and will require extensions or replacement. Many of these sewage treatment plants are small and do not require a full-time operator; consequently, there is a comparatively small number of experienced operators available. The result is a limited number of trained personnel who might be interested in a transfer to a new treatment plant.

Status of Treatment Facilities

Using the best available information for towns and cities having a population of 1,000 or more, Table I has been prepared showing the total population by provinces (1951 Census), and the number of persons served by partial or complete sewage treatment. At best, this can only be an approximation but it does present some idea of the present status of municipal sewage treatment in Canada.

There are, of course, thousands of smaller installations for individual homes and small institutions. These are usually septic tanks.

These data do not include treatment plants constructed and operated by the Canadian Government. Many of these plants are small in size and there are wide fluctuations in the populations served, particularly those located at military camps. The construction of housing facilities at military camps in recent years has had a tendency to reduce these population variables and

TABLE I.—Canadian Municipal Waste Treatment Data by Province

Province	Population Total	Population Served	
		Partial Treatment	Complete Treatment
Alberta	939,500	345,650	45,300
British Columbia	1,165,210	10,950	32,800
Manitoba	776,541	373,700	16,000
New Brunswick	515,697	2,200	0
Newfoundland	361,416	0	0
Northwest Territories	16,004	—	—[2]
Nova Scotia	642,584	0	0
Ontario	4,597,542	1,130,570	1,019,500
Prince Edward Island	98,429	0	0
Quebec	4,055,681	34,950	4,700
Saskatchewan	831,728	13,200	159,150
Yukon Territory	9,096	—[1]	—

[1] Primary treatment planned for Whitehorse (population 3,500).

[2] Complete treatment provided at Yellowknife (population 1,500).

at the same time has contributed, in some cases, to an overloading of the existing treatment facilities.

Using a minimum population of 500, a summary of the population served by sewage treatment plants operated by the Canadian Government in the various provinces has been prepared and is shown in Table II.

Again it is necessary to emphasize that these populations are probably far from accurate because of the wide fluctuations in population at various sites. Taking them at face value approximately 170,000 persons are served by sewage treatment plants on Federal property. There is in addition a large number of small treatment plants serving population of less than 500 persons. These smaller installations were installed and are being operated by every Federal department having staff on duty outside of Ottawa. Included are nursing stations, hospitals, customs and immigration offices, agricultural stations, national parks, historic sites, residential schools, soldiers settlements and Veterans Land Act developments, and many others. These small treatment plants pose many problems. It is not easy to obtain data essential to proper design and the small size makes it uneconomical to provide engineering control of the installation, even if additional staff were available from the Federal Government.

Current Problems

Climatic conditions play an important part in the design and operation of Canadian waste treatment plants. The permafrost areas of the far north present the most difficult problems. Present research on ground temperatures by the National Research Council and the Department of National Health and Welfare may help solve some of the difficulties encountered. The Department of Northern Affairs and National Resources is also interested in this project.

A recent development of major importance to all concerned with waste treatment concerns two court decisions in Ontario. In both instances riparian owners on streams receiving treated sewage effluent were awarded damages, and injunctions were issued providing a specific date after which further contamination of the streams is forbidden. The judgments are being appealed and the decision of the higher court is awaited with keen interest by pollution control authorities. If the

TABLE II.—Summary of Sewage Treatment Facilities Operated by the Canadian Government

Province	Population Served	
	Partial Treatment	Complete Treatment
Alberta	11,500	6,500
British Columbia	4,600	3,000
Manitoba	5,000	10,300
New Brunswick	9,000	13,000
Newfoundland	3,500	5,000
Nova Scotia	5,000	3,000
Ontario	39,550	26,000
Prince Edward Island	—	1,500
Quebec	17,450	—
Saskatchewan	3,600	1,800
Yukon and Northwest Territories	3,000	—

judgments are upheld it will mean that all parties discharging wastes into surface waters will be subject to damages and injunctions since it would be almost impossible to produce an effluent which would not degrade the receiving waters to some degree.

Conclusion

This, then, is a brief review of sewage disposal methods and controls in Canada with some municipal data provided by way of contrast. Little has been said regarding the treatment methods used in Federal installations but examples of most of the presently accepted methods are to be found. It is felt that the Canadian Government has been doing a better than average job in this field. Sometimes desirable action may be unduly delayed and results are not always as good as should be expected. However, there is reason to believe that a growing public interest in pollution abatement is developing and as a result careful design, construction and operation of waste treatment plants of all kinds will be rewarded by the approval of all whose interests are involved.

CANADIAN SEWAGE WORKS STATISTICS*

Provinces	Sewer Systems (no.)	Population Served	Per Cent of Total Population Served	Sewage Treatment Plants			
				Total Number of Plants	Partial Treatment Plants	Activated Sludge Plants	Trickling Filter Plants
Alberta	145	475,000	51.1	138	66	6	7
British Columbia	51	655,000	53.2	18	12	2	4
Manitoba	28	415,000	51.4	14	9	0	5
New Brunswick	29	188,000	35.1	1	1	0	0
Newfoundland	18	128,000	32.4	1	0	0	0
Nova Scotia	37	290,000	43.7	0	0	0	0
Ontario	207	3,300,000	67.5	208	128	60	20
Prince Edward Island	3	30,000	28.4	0	0	0	0
Quebec	265	2,220,000	52.0	64	61	1	2
Saskatchewan	41	288,000	34.2	45	12	8	7
Total	824	7,969,000	54.2	489	289	77	45

* *The Municipal Utilities Magazine*, 91, 1, 4 (1956).

Industrial Wastes

RADIOACTIVE WASTE DISPOSAL AT HANFORD *

By Royal E. Rostenbach

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With the passage of the Atomic Energy Act of 1954, many more persons, companies and associations interested in the peacetime use of atomic energy are giving attention to the disposal of radioactive wastes. This attention is required since all radioactive wastes must be disposed of in an acceptable manner. This includes not only the wastes from large installations such as those of the United States Atomic Energy Commission but also those in small quantities resulting from medical, experimental and other uses.

General Considerations

The general philosophy, principles and practices used in the disposal of sewage and industrial wastes have been applied to the disposal of radioactive wastes from the early days of the Manhattan District projects. Since then much progress has been made through research and development in this field. Improvements and new approaches in handling, treating and disposing of these wastes have been introduced. The primary objective has been to ensure that radiation from the wastes shall not exceed certain maximum permissible levels and concentrations. Just as we are learning, day by day, more about the treatment and disposal of sewage and industrial wastes, so we must learn to treat and dispose of radioactive wastes from many more new uses.

The environment of an operation plays a large part in the disposal of

* Presented at the 1955 Annual Meeting, Pacific Northwest Sewage and Industrial Wastes Assn.; Victoria, B. C.; Oct. 27–29, 1955.

ATOMIC ENERGY ACT OF 1954

Public Law 703, 83rd. Congress, approved August 30, 1954, greatly enlarged the opportunities for peacetime uses of atomic energy. Known as the Atomic Energy Act of 1954, it makes the Atomic Energy Commission the operating entity in the field.

The Act provides for research in atomic energy and its applications; authorizes the licensing of facilities to utilize atomic energy; and specifies various restrictions on the use of radioactive materials or their by-products. The declassification of heretofore restricted data permits access to essential material to facilitate both the research and use of atomic energy.

This paper by Dr. Rostenbach emphasizes the need for free exchange of information in the field of radioactivity. We may all profit by reading and studying work in this field. With increasing peacetime use of radioactive materials, we may find resulting wastes in our treatment plant influents at any time.—The Editors.

radioactive wastes as it does in the disposal of other wastes. The physical environment of an area or location governs, to a great extent, the treatment and disposal practices which must be used. In some areas the environment demands that extreme care be taken to dispose of wastes so that unhealthy or nuisance conditions will not develop and that the minimum permissible concentrations established by law will be met. In the disposal of radioactive wastes the industry has initiated practices to protect employees and the inhabitants of the surrounding area from radiation exposure in excess of recommended national limits. To achieve this purpose, the nature, quantity and quality of radioactive wastes must be known. It is also necessary that the environment into which these wastes are to be disposed be controlled and the limits recognized in terms of maximum permissible concentrations or radiation levels.

In the treatment and disposal of sewage and industrial wastes certain units and standard methods of analysis have been formulated, based on years of experience. Similarly, the atomic energy industry has developed appropriate units and methods of analysis to evaluate the exposure to radiation. In order to treat and dispose of radioactive wastes, it is necessary to know and understand these systems of evaluation.

Since all living things can be affected by radiation, the potential hazard of radioisotopes in radioactive wastes is one of the primary controls used in establishing what should be done with the wastes. It follows that intelligent evaluation of any radioactive wastes disposal problem requires an understanding and appreciation of the radiological, biological, physical, and chemical factors of each radioisotope, or each group of them.

Personnel employed in the handling, treatment and disposal of radioactive wastes must be protected against exposure to radiation from these wastes. It is the responsibility of management to provide the necessary protection, facilities and monitoring control for this purpose. Protection standards must be established based on the best information which is available and is applicable to the radiation problem associated with each job. It follows that, as a matter of routine, analytical surveys must be made to establish the fact that the protective standards are met. Special laboratory facilities or ations. People especially trained are required to use analytical equipment, to make necessary calculations, to use the acceptable units, and to interpret the results. As the atomic era progresses, familiarity with these ways and means of control will be as common as an understanding of B.O.D. is to those experienced in today's methods of sewage treatment and disposal.

Governmental Regulation

The expanding national use of atomic energy has led governmental agencies to consider rules and regulations which would provide adequate control of such energy and protection against radiation. These would also be directly applicable to radioactive waste disposal problems.

The question comes up as to how much can be accomplished through laws and regulations governing the disposal of radioactive wastes on a state or national basis. The answer depends on the kind of laws and regulations under consideration. One type might set up narrow limits and conditions which could not be exceeded under any circumstances. Another type might be designed primarily for the purpose of establishing broad policy. Local, state, regional and national problems of waste disposal have many characteristics in common for which codification of broad general

principles is logical but it is difficult to codify a subject in a relatively new technical field when new information is being developed daily. It might be better to continue the present practices under which standards are determined from the best available information, research and development rather than to attempt a detailed codification at this time. Standards and limits may then be adjusted upwards and downwards readily as new knowledge becomes available. It is usually more expeditious to revise a manual or handbook than to revise a legal code by due process of law. Specific reference is made to the Handbooks of the National Bureau of Standards (1) (2)(3)(4)(5)(6)(7)(8).

Information Exchange

The discussion of radioactive waste disposal was a major part of the program at the International Conference on Peaceful Uses of Atomic Energy in Geneva during August, 1955. The collected papers of this conference will be an important source of information on the current status of this problem. The international aspects of radioactive waste disposal were discussed at the conference at some length and it seems probable that appropriate international attention will be given to the study of this problem.

The Geneva meetings are evidence of what can be done in the exchange of unclassified information. If there is to be broad application of atomic energy to peacetime use, information must be disseminated to all who are interested in it. Scientific and technical progress is made through the exchange of information and ideas. The disposal of radioactive wastes is just one subject in which progress can be made, but it is an extremely important one. The Federation of Sewage and Industrial Wastes Associations can be instrumental in the dissemination of information through the meetings of its member Associations and through the Federation Journal. The subject of treatment and disposal of radioactive waste has received some attention. More time in meetings and more space in the Journal should be allocated to it to keep the members and the public abreast of new developments in radioactive waste disposal and control in the peacetime uses of atomic energy.

Hanford Atomic Products Operation

In this connection, the author feels it appropriate to outline briefly the radioactive waste disposal and control programs at the Hanford Atomic Products Operation. The program of this large installation illustrates many important points relative to the treatment and disposal of radioactive wastes.

The wastes of primary concern are:

1. Cooling waters of the nuclear reactors.
2. Gases from the reactors and chemical processing areas.
3. Liquids from chemical processing areas.
4. Solids resulting from all operations. In general, the radioactive waste program is to concentrate and retain certain wastes under controlled conditions and to dilute and disperse other wastes under specific conditions.

Environmental Factors

The importance of environment in solving the problem of disposing of radioactive wastes has been mentioned previously. Therefore, it is necessary to describe and to discuss the environs of the Hanford operation.

The Hanford project area is located on the Columbia River directly above the confluence of the Yakima and Columbia rivers in the south-central part of the state of Washington. The reservation is approximately 620 square miles in area. The residential city of

Richland and headquarters of Camp Hanford are situated on the west side of the Columbia River directly above the mouth of the Yakima River. Approximately 9 miles downstream from Richland are the communities of Kennewick and Pasco on the west and east banks of the Columbia River, respectively. The urban and rural population of the immediate area is approximately 80,000.

In the late summer and fall of 1953 the large reservoir behind McNary Dam, a hydroelectric power and navigation facility, was established on the Columbia River. The dam is located approximately 45 river-miles below Richland and directly above Umatilla, Oregon. The reservoir is approximately 60 miles in length, hence extending 15 miles above Richland. Into this reservoir the Yakima, Snake, and Walla Walla rivers discharge. Already a number of parks and fish and wildlife reserves have been developed along the reservoir.

Across the Columbia River, to the north and east of the Hanford reservation, is the Columbia Basin Project which is being developed by the United States Bureau of Reclamation with water from Lake Roosevelt behind Grand Coulee Dam. In the next few years this irrigation project will substantially increase the rural population of the area. Since 1948 the water for the Pasco irrigation area has been pumped from the Columbia River at a point 7.5 miles above Richland. It is reported that, after equilibrium is reached, approximately 64 per cent of the irrigation return water of the project will enter the Columbia River above the Hanford reservation as ground and surface water and approximately 36 per cent will be discharged into the McNary reservoir below the reservation.

Kennewick and Pasco use Columbia River water for their municipal water supplies. Kennewick has infiltration galleries and slow-sand filters located along the river. The Pasco water supply is treated by coagulation, sedimentation and filtration. Richland and Camp Hanford secure their sanitary water supply from wells in the immediate vicinity. During the summer months some of the well fields are recharged by surface ponds supplied with Yakima River water. All sanitary water supplies are chlorinated prior to distribution.

From the foregoing, it is evident that the Columbia River below the Hanford operation is used for sanitary water supply, irrigation, navigation, hydroelectric power, fish and wildlife and recreation. These uses are all considered in the Hanford waste disposal program which is related to the river.

Treatment of Radioactive Wastes

Columbia River water is used as a coolant for the nuclear reactors. The water is first treated and filtered by conventional methods (9). In its passage through the reactors, the coolant becomes radioactive due to the neutron bombardment on certain dissolved solids. Large retention basins have been provided to hold this water for a period of time since most of the radioisotopes have rapid decay rates. The cooling water, with its limited concentration of radiosotopes, is then discharged into and mixed with the main body of the Columbia River. As the mixture flows down the Columbia the remaining radioisotopes continue to decay with the passage of time. By the time it arrives in the Richland area, the reactor effluent water essentially is uniformly diluted with the water of McNary reservoir. With the dilution by the Yakima, Snake, and Walla Walla rivers, the radioisotope concentration is further reduced. The concentration is very important from a public health protection point of view and it must be kept below the maximum permissible concentration.

In general the limited sediment carried by the river tends to concentrate the radioisotopes from the surrounding water. This material, when it settles, is incorporated into the river bottom and shore. Attention has been given to the concentration of radioisotopes in the muds which settle in the McNary reservoir.

Radioactive decay, or the rate of disintegration of a radioisotope, governs to a great extent the methods used in the disposal of radioactive wastes. Radioisotopes with short half-lives of a few minutes may be held for short periods of time under controlled conditions and the radiation effects are minimized. Radioisotopes with long half-lives of hours, days, and years, however, require special handling.

Gaseous wastes result from extraction of plutonium and the recovery of unused uranium by chemical processes and from the ventilation of the reactor and processing areas. These wastes are subjected to chemical treatment, scrubbing or filtration before they are discharged through tall stacks to the atmosphere.

The liquid wastes resulting from the chemical processing plants are of two main types and must be handled differently. Those wastes which have a high level of radioactivity and long-life are stored in huge underground tanks. The remaining liquid wastes, which have a low level of radioactivity, are discharged to the ground under specific authorization and strict control (10). The solid wastes, including material and equipment subjected to neutron bombardment in the reactors or equipment handling radioactive liquid and similar waste, are buried.

Monitoring Control

The Radiological Sciences Department has the responsibility for the monitoring and control of radioactive waste disposal (11). For employee and public health protection an extensive inspection is carried on in the Hanford environs. Protective measures include the following:

1. The activity of the reactor coolant is continuously monitored before it is released to the Columbia River. The concentration of gross alpha and beta particle emitters and certain specific radioisotopes are monitored in the supplementary samples of the water. These samples are collected on a daily to weekly basis at representative locations between the reactor areas and McNary Dam. Special attention is given to the Columbia River water supply of Pasco and Kennewick. From the McNary Dam to Portland, Oregon, a distance of approximately 193 river miles, samples are collected on a monthly basis.

2. Mud samples are taken usually at the time the river water samples are collected. The possible effects of radiation on the ecology of the Columbia River are studied and no adverse effects have been observed to date (12).

3. Since livestock and crops are steps in the food-chain relationship for man, many samples of vegetation from the Hanford environs are analyzed for the extent and degree of concentration of radioisotopes deposited by effluent gases. Approximately 70 per cent of these samples is taken in the immediate environs and the remainder is collected in remote sections of Washington and Oregon.

4. Gas samples are collected directly from the plant stacks and discharge ducts. Continuous filter and scrubber samples are collected. The concentrations of radioisotopes in these samples are determined and reported.

5. The radioactive concentration from airborne materials and radioactive materials on the ground is determined by specific instruments. These surveys are made at the perimeter of

the production areas, near the residential areas surrounding the plant and at remote monitoring stations throughout the Northwest (13).

6. The concentration of gross beta particle emitters is determined periodically in rainfall samples collected at random locations.

7. With reference to wastes discharged into the ground, sub-surface water samples are collected from monitoring and sanitary water wells within and without the project area. The radioactivity determinations are made on weekly or monthly basis depending upon the area and use of the water.

8. Within the plant, instrument surveys are performed at the perimeter of the open waste areas and along the various ditches which discharge into retention areas.

Alpha and beta particle emitters in the Columbia River below Richland, Wash. are considerably below one-tenth of the recommended maximum permissible concentrations of the National Bureau of Standards Handbook (5). Similarly, more conservative maximum permissible concentrations are not exceeded in the sanitary well water supplies and in the air of the Hanford environs.

Research and Development

Scientific research and development are used at Hanford to advance the knowledge of the technical, economic, and employee health, and public health aspects of radioactive waste disposal. Considerable work is done on analytical techniques to improve the measurement of the quality and quantity of radioisotopes wherever they are found. Basic considerations in chemistry, physics, biology and electronics are a part of this work. Experimental and synoptic meteorology are important sciences at Hanford in the consideration of airborne radioactive gases and particles. Investigations of the ground, ground water and general geologic studies are fundamental to the disposal of radioactive wastes to the ground in the Hanford area. Studies in the biological sciences are carried on to advance the understanding of the effects of radioactive waste disposal on aquatic and animal life in the food-chain relationship of man (14)(15)(16).

Interrelation with Other Agencies

The research and development investigations are conducted by highly qualified technical personnel. Similarly the engineering and operating problems of radioactive waste disposal receive the attention of equally competent engineers and scientists. State and federal public health officials are kept informed of the waste disposal and control programs through an advisory group of these officials. They in turn advise on matters of public health significance.

Summary

The disposal of radioactive waste must receive due attention in the peacetime use of atomic energy. Maximum permissible concentrations should not be exceeded and exposure to radiation should be kept at the lowest practicable level.

The wastes disposal and control programs of the Hanford operations have been outlined. The liquid, gaseous and solid radioactive wastes are disposed of under controlled conditions with due consideration to the protection of employee and public health. Monitoring of the environs insures that standards for radioactive waste treatment and disposal are being maintained. Research and development in the basic and applied sciences assist in improving present methods and lead to better, safer and more economical programs of radioactive waste disposal. Federal and state agencies cooperate in the program.

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MEMBERSHIP DIRECTORY

The Annual Membership Directory and Year Book reflects the strong membership growth of the Federation Member Associations since the last complete directory was published in 1954. The 1956 listing includes more than 6,800 names, addresses and professional occupations of the membership as of December 31, 1955. In addition to this listing, the directory includes a Geographic Listing of the membership by states or countries and cities. A member can now acquaint himself with persons of similar interest by referring to this handy summary.

The Annual Year Book for 1956 presents an up-to-date roster of Federation committees, award recipients and officers. Continued favorable growth of the Federation should result in the next publication of the complete directory as a separate number in 1958.

WASTE TREATMENT IN THE PULP, PAPER AND PAPERBOARD INDUSTRIES *

By Harry W. Gehm and Nicholas J. Lardieri

Respectively, Technical Advisor and Regional Engineer, National Council for Stream Improvement, Inc., New York, N. Y.

Approximately five years ago a survey of water usage and waste treatment in industry by the National Association of Manufacturers revealed that 37 per cent of all the paper mills in the United States had waste treatment facilities. Since then the construction of waste treatment plants in the pulp and paper industry has proceeded at an accelerated rate. A recent survey of 329 mills by the staff of the National Council for Stream Improvement, Inc. indicated that 180, or 55 per cent of the mills in the survey sample, have constructed waste treatment plants of one type or another. This indicates substantial pollution abatement, particularly when it is considered that many pulp and paper mills are fortunately situated at locations where abundant flows in receiving streams or tidal water discharge make waste treatment facilities unnecessary. Based on this recent survey it can be conservatively estimated that the industry has spent in the neighborhood of $70 million for waste treatment plant construction during the past 10 years.

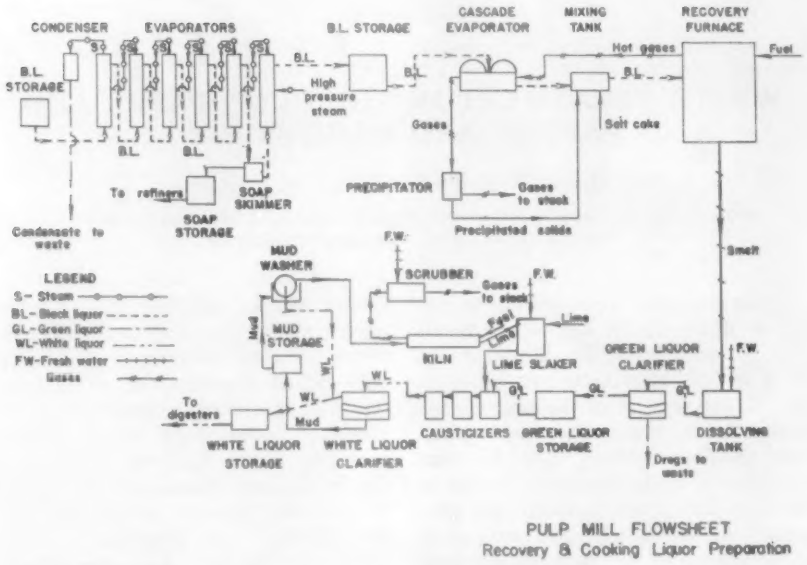
Three quarters of the pulp manufactured in this country is produced by the kraft process. Of the 78 mills in operation, the greatest number and largest kraft units are located in the Southern United States. Typical of the integration in the kraft process is the highly efficient spent liquor recovery system (Figure 1). A completely closed pulp washing system delivers the spent cooking liquor to multiple effect evaporators. These are followed by cascade evaporators in the recovery boiler stack which concentrate the liquor to a degree where it can be burned. Steam produced from burning the liquor is employed to run the mill and cook chemicals recovered from the vapors. Improvements in this process which have taken place during the past 10 years have raised the efficiency of the recovery process to well over 95 per cent. Because of this, the effluent from the process is weak in strength, having in many cases a lower B.O.D. than sanitary sewage.

Reduction in Pollution

The reduction in pollutional load in relation to production for the kraft industry is shown graphically in Figure 2. While production of kraft pulp has increased 300 per cent, the pollutional load is lower than it was in 1937. In one state the pulp and paper mills from 1937 to 1952 reduced their suspended solids pollutional load 65 per cent while production was increased almost 60 per cent above the 1937 index.

Pollution control by sulfite pulping operations is presented graphically in Figure 3 in relation to pulp production. It appears from this plot that since 1942 the pollutional load from this source is no greater than it was in 1937 in spite of a production increase of 50 per cent. This has re-

* Presented at 28th Annual Meeting, Federation of Sewage and Industrial Wastes Assns.; Atlantic City, N. J.; Oct. 10–13, 1955.



PULP MILL FLOWSHEET
Recovery & Cooking Liquor Preparation

FIGURE 1.—Schematic diagram of a flow sheet for spent liquor recovery in a kraft pulp mill.

sulted from the pollution abatement measures taken by the industry. A similar graphic presentation of production in relation to pollution load is presented in Figure 4. This shows that while production for the entire industry increased almost 100 per cent between 1937 and 1952, a 25 per cent reduction in the pollution load has been effected.

With the initial operation in August, 1955 of clarification facilities at a paper mill in Kalamazoo, Mich. the treatment of all pulp and paper mill wastes in the Kalamazoo River valley was accomplished. In this area alone, 9 mills are now in operation, seven of which treat a combination of white water and de-inking washer waste. These units remove more than 98 per cent of the settleable solids from the wastes.

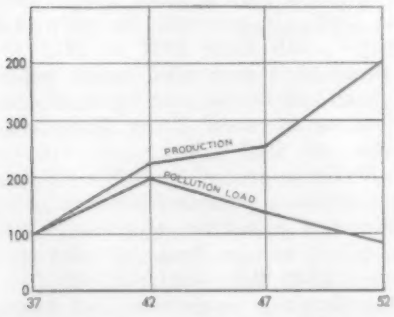


FIGURE 2.—Pollution load reduction by the kraft pulp mills, 1937–52.

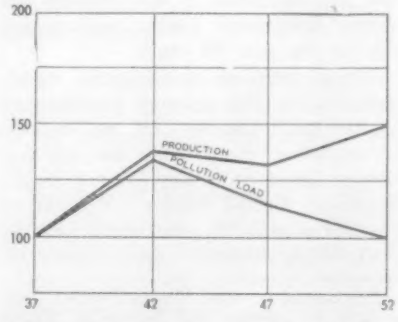


FIGURE 3.—Pollution control effected by sulfite pulp mills, 1937–52.

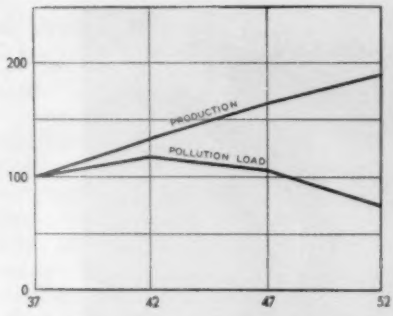


FIGURE 4.—Pollution control effected by the pulp paper and paperboard industries, 1937–52.

Treatment Methods

The following presentation illustrates some of the more common methods of waste handling employed in the pulp, paper and paperboard industries, together with individual and collective performance in respect to pollution abatement accomplished. Control measures are a function of the mill location relative to the receiving water, the type of operation and the economics involved in the particular situation.

As in the past, the major pollution characteristic of waste effluents from the pulp and paper industry is the B.O.D. exerted on the receiving water. A secondary characteristic, the importance of which may vary with the specific situation, is the presence of suspended or floating solids.

Clarification

Methods for the removal of suspended matter from machine water, integrated mill wastes and deinking washer waters usually utilize clarification processes of one type or another. Clarifier installations may vary from a simple unit (Figure 5) for deinking waste treatment to a part of the complex system for treating paperboard mill effluent to a degree where the bulk of the effluent can be returned to the manufacturing process for reuse. Side-hill screens and deaerators may precede the clarifiers, and rapid sand filters of the automatic continuous back wash type may be used to polish the effluent so that it is sufficiently clean for use in high pressure services.

Numerous sludge blanket type clarifiers are employed for the clarification of both board mill and paper mill effluents. Activated silica and alum are the most commonly used coagulants. Suspended solids reduction exceeding 90 per cent can be obtained with this type of equipment.

Removal of suspended matter from kraft mill effluents through the use of earthen bank basins, equipped with sludge collection mechanisms (Figure 6), is undergoing full-scale experimentation in the South. Such an installation saves considerable cost where large volumes of effluent must be treated, since the scraper mechanisms can be built with diameters of 200 ft. or more.

The large and complicated waste treatment plant shown in Figure 7 serves a mill which produces both sulfite and soda pulps, de-inks magazine stock and has a multiple machine operation. Each paper making machine is equipped with save-alls and the combined effluent from the machine is then conducted to a large cyclator. Here the waters are treated with alum and activated silica and further clarified. A large percentage of this water

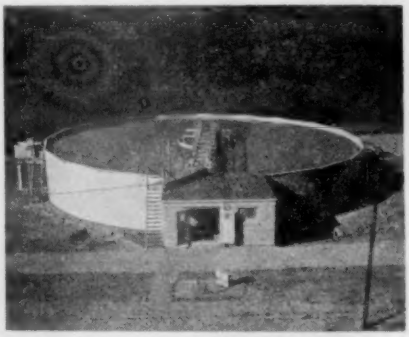


FIGURE 5.—Clarifier for treating deinking wastes.

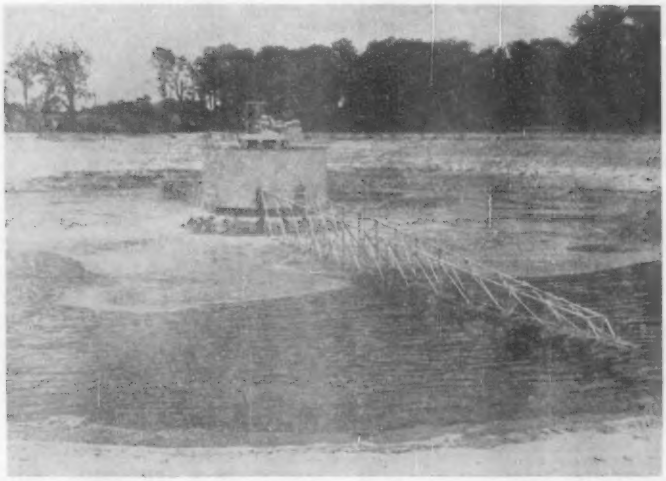


FIGURE 6.—A large earthen bank settling basin equipped with a sludge collector.

is returned to the paper machine rooms for reuse and the remainder is discharged to a sewer. A portion of the sulfite waste liquor is evaporated and sold and the remainder is lagooned seasonally.

Sulfite wash water, soda mill effluent and deinking washer water also are discharged to the common sewer. The combined waste is treated in the rectangular clarifiers shown in Figure 7. These units remove practically all the settleable solids and more than 80 per cent of the total suspended solids. The underflow is pumped to a large sludge basin on a plateau 300 ft. above the mill. This basin has a capacity for holding the sludge accumulation from many years of operation since the clear supernatant, which accumulates when the sludge thickens, is decanted.

FIGURE 7.—Extensive waste treatment facilities utilized by a progressive pulp and paper mill.

An installation treating asbestos paper mill effluent employs two stages of sedimentation followed by filtration through a cinder bed. Practically complete clarification is obtained by this technique.

Flotation is widely used for the clarification of white waters, particularly those produced in the manufacture of filled papers. In the operation of these devices, glue or activated silica is generally employed together with alum as a coagulant. Such devices, properly installed and operated, can produce effluents having a suspended solids content as low as 0.2 lb. per thousand gallons.

Thickeners are used for the clarification and recovery of pressboard effluent. Settleable solids are removed from the effluent, together with 90 per cent of the total suspended solids and much of the color. The underflow from the thickener is returned to the stock chest for incorporation in the manufactured product. The effluent is of sufficiently good quality to allow considerable reuse in the mill.

Mechanical Filtration

Fiber recovery from multiple machine operation is accomplished with vacuum filters. Various types of vacuum filters are employed in the pulp and paper industry for clarifying machine waters not containing fillers. In this service, they are generally capable of producing effluents containing less than 0.5 lb. of suspended matter per thousand gallons of effluent.

An interesting filter which has been developed recently is shown in Figure 8. This is a gravity filter employing a fourdrinier wire which runs around a drum. A thin wet sheet of sweetener stock is applied to the wire prior to its engaging the drum. This sheet serves as a filter medium as the wire progresses around the drum which is partially submerged in white water. With the use of sufficient sweetener stock these filters can produce an effluent containing less than 0.2 lb. of suspended solids per thousand gallons of waste.

It is almost invariably necessary to screen the bark and rejects from pulp mill wood room effluents. Generally, the screenings are dewatered by pressing and either burned in a bark burner or carted to a dump.

Sludge Disposal

All residues recovered from papermaking operations are not suitable for return to the process for one reason or another. Accordingly, the sludges obtained must be disposed of in a suitable manner. In some cases, the sludge is dried on sludge beds and in others, lagooned. Sludge dewatered by vacuum filters frequently can be combined with other materials and employed for land fill.

Underflow from rectangular clarifiers is commonly discharged to sludge drying beds. After thickening, the supernatant is allowed to drain and

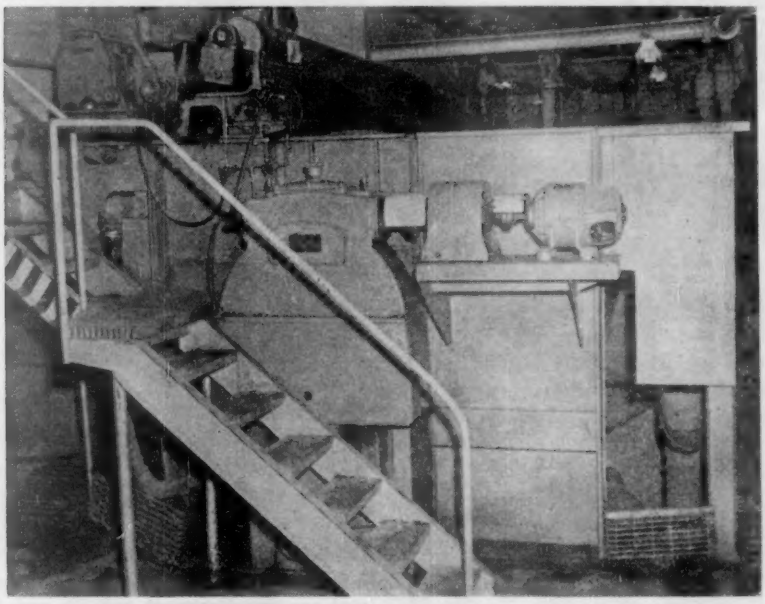


FIGURE 8.—A gravity filter employing a fourdrinier wire which runs around a drum and using sweetener stock as a filter media.

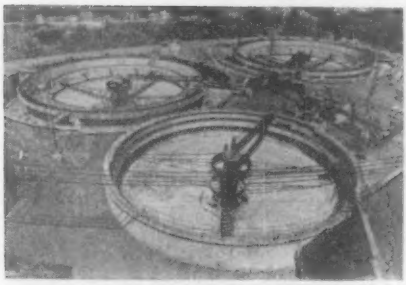


FIGURE 9.—An accelerated aeration treatment plant for treating 16 to 24 m.g.d. of kraft and bleachery wastes.

the sludge to partially dry. It is then removed and hauled to a dumping area.

Activated Sludge Treatment

The absence of sufficient waste land to provide for oxidation lagooning at some locations created a need in the kraft industry for a compact treatment process. Research conducted over a number of years by the National Council for Stream Improvement project at Louisiana State University indicated that a modification of the activated sludge process might be applicable to kraft effluents. To determine if this was the case, pilot plants were constructed by the industry. At the West Virginia Pulp & Paper Co. mill, Covington, Va. an accelerated aeration treatment plant (Figure 9) was designed to treat 16 to 24 m.g.d. of combined kraft and bleachery waste. It is expected to obtain a B.O.D. reduction of 80 to 90 per cent. An experimental aeration unit capable of treating 1,000 g.p.m. of decker seal pit water was recently put in operation at Lufkin, Texas. Here the treatment unit supplements oxidation lagooning. Treatment of part of the waste by the accelerated aeration process accelerates oxidation of the comibned effluent in the lagoons.

Experiments were also undertaken to determine feasibility of the accelerated aeration process for treating semi-chemical machine waters. This experimental unit (Figure 10) was designed to handle 1 m.g.d. of machine water and has been in operation for about one year. To date, the results obtained have not been as promising as those obtained for kraft effluents.

Other Treatment Processes

Spray Irrigation

One of the perplexing problems in pulp mill waste disposal has been unintegrated neutral sulfite semi-chemical mill effluents. Although most semi-chemical pulping is integrated with the kraft process so that the liquor can be burned, there are five mills where this process is employed separately. Recovery from these units is not an attractive proposition since the units are small, the liquor is low in chemical content and the recovery process is complicated. Therefore, in addition to research on recovery, other methods of disposal and treatment are being investigated.

Land disposal of dilute neutral sulfite semi-chemical liquors is practiced at one mill in South Carolina (Figure 11). The type of equipment employed is similar to that used for spray irrigation. This technique does not lend itself to wide application because of

FIGURE 10.—An experimental accelerated aeration treatment unit for reducing the B.O.D. from semi-chemical machine waste waters.

the large areas of pervious soil required for even a very small mill.

Lagoons

Because of highly valuable hydrographs and the large size of Southern kraft mills, the recovery system alone does not suffice for treatment of the wastes. Accordingly, many mills are equipped with oxidation lagoons (Figure 12). The large areas of available waste land, makes the use of this method most practicable for the Southern mill. On streams affected by tide, lagoons are often employed for discharge control regulation as well as oxidation. One oxidation lagoon facility serving a Southern paper mill produces a highly stabilized effluent. A high degree of solids removal is first obtained, followed by multiple oxidation basins and flow through a series of pools and riffles for a distance of seven miles. The B.O.D. of this effluent is reduced to about 10 p.p.m.

FIGURE 11.—Spray irrigation for land disposal of dilute neutral sulfite semi-chemical liquors.

Evaporation

Between 5 and 10 per cent of the total spent sulfite liquor produced in the United States is evaporated and sold for use in various adhesives, road binder and other commercial applications.

FIGURE 12.—Oxidation lagoons for pulp mill wastes.

Mechanical difficulties as well as the poor economic situation in respect to the recovery of calcium base spent sulfite liquor has led to the development of soluble base processes. One of these has been the magnesium bisulfite process. In this process, heat and chemicals are recovered to a degree similar to the kraft process. A view of typical recovery furnaces is presented in Figure 13. Another soluble base development is the ammonium bisulfite system. The sulfite liquor is evaporated and burned but ammonia recovery has not as yet proven practical. This plant also produces concentrates which are marketed.

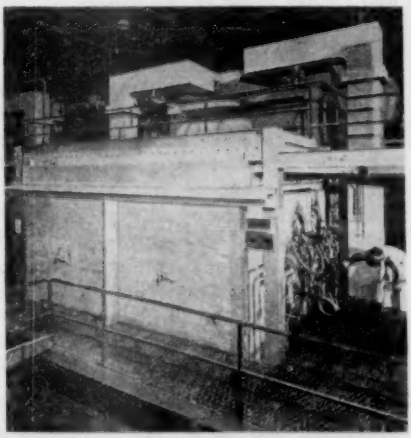


FIGURE 13.—Recovery furnaces for reclaiming magnesium bisulfite.

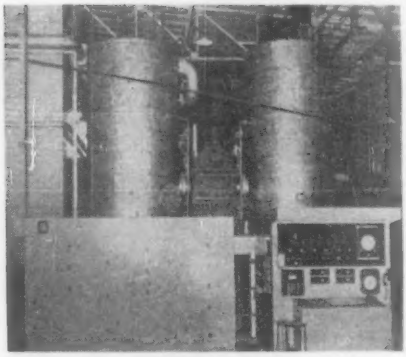


FIGURE 14.—Large-scale experimental evaporators for the recovery of calcium base liquor.

Development of special evaporators to control scaling during the evaporation of calcium base liquor has led to renewed interest in this recovery process. A large-scale experimental installation for the recovery of calcium base liquor employing Rosenblatt evaporators is now in operation (Figure 14). The steam and liquor sides of the evaporators are switched periodically to prevent fouling.

In general, competition mitigates against widespread use of spent liquor fermentation processes. However, ethyl alcohol is produced at one mill and fodder yeast at two others.

Waste Disposal

Research, development and application in respect to acid sulfite spent liquor disposal has been studied from a number of different aspects since no one arrangement is suitable for all mills and locations. In a number of instances, seasonal storage of the liquor is effective for controlling pollution. One stream on which this method is widely used is the Willamette River in Oregon. This stream provides adequate dilution for 10 months of the year. The mill, therefore, provides a stabilization basin for storage during the months when stream flow is inadequate for proper dilution of the waste.

As the South provides large areas of waste land for lagooning, the Northwest conveniently provides large bodies of water to permit stream dispersion, deep water discharge and barging (Figure 15) to be successfully employed to control pollution. In Oregon, Washington, Wisconsin and Michigan, both acid sulfite and neutral sulfite semi-chemical liquors are disposed by employing them as road binder. This method of disposal is seasonally advantageous since the season in which roads are dressed and low stream flows occur correspond.

Experimentation with the "Zimmerman Process" for handling neutral sulfite semi-chemical liquor is underway in a large-scale pilot plant. This process is basically one of wet combustion in which the liquor is heated in the presence of high pressure air and the organic carbon oxidized to carbon dioxide and water. Tests are directed to determine the degree of combustion, chemical recovery and heat recovery.

Conclusion

Today, progresive companies in all fields of industry are examining their current waste treatment position and making long range plans to maintain or improve their relative position in their particular industry. Undoubtedly many state agencies are likewise

FIGURE 15.—Barging spent sulfite liquor, Oregon.

evaluating their present and future relative position in the national economy. There would seem to be a fruitful field here for state agencies entrusted with economic planning and industrial development. Obviously, the state that does not get its proportionate share of industrial growth must resort to other means to sustain its increased population which, in most cases, depends on the industrial economy for its support. Industry, of course, will locate and expand in states where conditions are most favorable and where water pollution controls are equitable. This would indicate the necessity for cooperation between various state agencies and industry in pollution control to the end that industry may develop and expand, thus make its proper contribution to the industrial economy of the state.

The pulp and paper industry has an enviable record of cooperation with regulatory agencies on all levels. Fortunately, most state and federal agencies are also aware of the necessity for such cooperation. This cooperative relationship must be fostered and developed further.

MEETINGS OF INTEREST

1956

April 13–16	**United States–Mexico Border Public Health Association,** Calexico, Calif.–Mexicala, Baja, Calif. Fourteenth Annual Meeting. Sidney B. Clark, M.D., Secretary, 243 U. S. Court House, El Paso, Texas.
April 15–17	**Western Public Works Conference,** Oakland, Calif. General Chairman, John A. Morin, City Engineer, City Hall, Oakland, Calif.
April 17–18	**Ninth Municipal and Sanitary Engineering Conference,** University of Florida, Gainesville, Fla. Dr. E. R. Hendrickson, College of Engineering, University of Florida, Gainesville, Fla. Conference theme—Atmospheric Pollution.
May 4	**Annual Conference for Engineers,** College of Engineering, Ohio State University, Columbus, Ohio.
May 6–11	**American Water Works Association Diamond Jubilee Conference,** St. Louis, Mo. Harry E. Jordan, Secretary, AWWA, 2 Park Ave., New York 16, N. Y.
May 12–15	**German Engineers Association Centenary Celebration.** Verein Deutscher Ingenieure Prinz-Georg-Strasse 77/79, Dusseldorf, Germany.
May 15–17	**Eleventh Purdue Industrial Waste Conference,** Purdue University, Lafayette, Ind. Professor Don E. Bloodgood, School of Civil Engineering, Lafayette, Ind.
June 4–8	**American Society of Civil Engineers,** Knoxville, Tenn.
June 18–22	**Gordon Research Conference on Stream Sanitation,** Kimball Union Academy, Meriden, N. H. Dr. W. George Parks, Director, Gordon Research Conferences, University of Rhode Island, Kingston, R. I. Applications necessary by April 1.
June 18–23, and 25–30	**Bioxidation of Organic Wastes,** Manhattan College, New York, N. Y. Assistant Professor W. Wesley Eckenfelder, Civil Engineering Dept., Manhattan College, New York 71, N. Y. Special course limited to 18 persons at each of two sessions.
Aug. 22–24	**Hydraulics Division, American Society of Civil Engineers,** University of Wisconsin, Madison, Wis. Professor Arno T. Lenz, College of Engineering, University of Wisconsin, Madison 6, Wis.

SETTLING BASIN DETENTION TIME BY RADIOTRACER *

By William Seaman

American Cyanamid Company, Research Division, Bound Brook, N. J.

Several methods have been used in studying the flow characteristics of settling basins. For example, flow has been traced by mechanical devices such as floats, or by adding dyestuffs or high concentrations of salt and determining the time between their addition to the inlet of the basin and their appearance at the outlet. None of these methods was considered to be quite satisfactory for determining the detention time of effluent in a large settling basin of the American Cyanamid Company at Bound Brook, N. J. This paper presents a solution of the problem based on the use of radioactive potassium-42.

The use of radioactive tracers has been reported on a number of occasions for applications involving a study of the flow characteristics or the velocity of water systems and of the detention time in a sanitary sewage settling basin. The author is not, however, aware of the use of such tracers for a study of the detention time of effluent in an industrial effluent settling basin.

Historical Review

C. N. Allen and E. A. Taylor (1) described the so-called salt-velocity method of water flow measurement. This involves the addition of salt solution to the upper end of a conduit or basin and measurement of the time necessary for the salt to arrive at points downstream. The time of arrival of the salt, as well as its concentration, may be measured either by titration of samples taken at downstream points or by conductivity measurements. From this information a curve may be plotted relating time necessary for the salt to appear at any given downstream point versus the concentration of salt or deflection of the ammeter needle. C. H. Capen, Jr. (2) discussed this method in relation to the determination of the efficiency of sewage settling tanks. Another somewhat related technique, the salt-dilution method, has been described by B. F. Groat (3). This method involves adding large quantities of a salt solution to a stream in a constant amount and at a known concentration, taking samples of the mixed flow downstream after a steady state has been reached and determining the concentrations.

Radioactive substances are capable of detection in extremely minute quantities. The tracer, itself, thus does not influence the flow, which is not always true of some other methods. The use of tracers, therefore, has been considered by some investigators for studying problems in water flow. The first discussion of such an approach was that of J. Joly (4) who described a proposed plan for introducing a solution containing radium (in the form of an acid pitchblende solution) into a stream and measuring the concentration of radium (through the evolved radon) at downstream points by means of an electroscope.

V. F. Hess (5) reported the use of radium as a tracer for flow measure-

* Presented at 28th Annual Meeting, Federation of Sewage and Industrial Wastes Assns.; Atlantic City, N. J.; Oct. 10–13, 1955.

ments in tank experiments by using the salt-dilution method. He also measured the activity of the evolved radon, using an ionization chamber. Unfortunately this method is extremely time-consuming and cumbersome. Losses by precipitation of 10 to 20 per cent of the radioactivity occurred over a period of several weeks when the method was tried on river water in a laboratory experiment.

S. Karrer, D. B. Cowie, and P. L. Betz (6) used the salt-dilution technique to measure successfully the flow of condenser water with radioactive sodium as the tracer and a dip-tube Geiger counter as the detector. They chose sodium, among other reasons, because considerable sodium was already present in the cooling water and thus there would be no question of the loss of radioactive material. R. S. Archibald (7) recommended the use of iodine-131 as a radiotracer in the salt-velocity method to determine the flow rate of sewage in a pipe. In addition, he reported satisfactory results with both laboratory and field tests using iodine-131 to determine the detention time in a pond and in a sedimentation tank of an activated sludge plant.

Bromine-82 was used (8)(9)(10) to measure detention time in a sewage purification basin, and to obtain contour curves of radioactivity in the basin. It also was used for similar purposes in lakes and storage basins. Underground movements of water have also been studied (11) using this radiotracer.

In other studies, the velocity of flow of digested sludge in underground sludge pipe lines was determined by means of small rubber sponges saturated with bromine-82-tagged ammonium bromide. Rubidium-86 has been used to determine flow-through curves of sewage sedimentation tanks and sodium-24 has found use as a tracer to measure velocities in large diameter pipes carrying circulating or cooling water to condensers of turbo-alternators. Cobalt-60 also has been used to measure the flow of water in mountain springs in order to determine the water content of snow packs (12).

Choice of Radioisotope

In considering the use of radiotracers to determine the detention time in the Bound Brook settling basin, questions had to be answered concerning both safety and the likelihood of obtaining positive information. It was essential to use a radioisotope and a technique which would introduce no hazard to personnel and which would not lead to the danger of depositing long-lived radioactivity in the basin or receiving river or of introducing an excessive amount of radioactivity temporarily into the river. R. S. Archibald (7) had carried out experiments with iodine-131 in either fresh water or sanitary sewage. However, in an industrial effluent, with a great variety of substances, there was a possibility that the loss of iodine might occur by physical or chemical means. This would make a clear-cut interpretation of the experiment doubtful. Furthermore, the expected great dilution would make the use of a radioisotope with more energetic radiation desirable.

It seemed more promising to use a radiotracer such as sodium-24 or potassium-42, since neither of these would be likely to form insoluble compounds. Sodium-24 has a half-life of 14.9 hr. and decays to yield a beta ray of 1.39 m.e.v. (million electron volts) energy and two gamma rays of 2.758 m.e.v. and 1.380 m.e.v. Potassium-42 has a half-life of 12.44 hr. and decays to produce a gamma ray of 1.51 m.e.v. and two beta rays of 3.58 m.e.v. and 2.04 m.e.v.

Potassium-42 was preferred for several reasons. The much more penetrating and energetic gamma ray produced by sodium-24 would make for a more difficult personnel protection

problem. The more energetic beta rays produced by potassium-42 would not complicate the safety problem to the same extent as the more energetic gamma rays would, and at the same time they would simplify the detection of radioactivity at high dilutions. The half-lives of both isotopes were rather short. This is advantageous from a safety point of view inasmuch as the radioactivity introduced into the basin and the river would decay rapidly. However, it did present a difficulty because it was necessary to make arrangements to receive the isotope from the Brookhaven National Laboratory with the least possible delay and to introduce it into the basin as quickly as possible.

Safety Precautions

In using a radioisotope such as potassium-42 which has highly energetic gamma and beta rays, the usual precautions familiar to workers with radioisotopes must be taken. These include the use of lead bricks for shielding when making dilutions and transferring the isotope. Long tongs are used to increase the distance between the technician and the radioactive preparations, and of course, work must be done as expeditiously as possible. Assistants must be thoroughly instructed and should participate in several "dry" runs before the experiment is undertaken, to insure the carrying out of the experiment with as little delay as possible. All those concerned should wear washable laboratory coats and film badges for recording radiation exposure dosage. In none of the experiments to be described did anyone concerned receive a radiation dosage which even approached the maximum tolerable level.

Exploratory Laboratory Experiment

Assurance was needed that, in the projected experiments, potassium-42 in the form of potassium carbonate would not be lost to any significant extent by physical or chemical reaction with the effluent. It was also necessary to determine whether or not the potassium-42 could be counted with sufficient accuracy in the dilutions contemplated. To get this information, experimental laboratory work was performed.

One unit of potassium-42 was received which consisted of 2.8 g. of neutron-irradiated potassium carbonate (anhydrous) with an estimated radioactivity at the time of withdrawal from the graphite reactor of 155 millicuries (mc.). The unit was dissolved in 1 l. of water in a 1,200-ml. stainless steel beaker. To one each of four stainless steel, 1,200-ml. beakers and to one each of four Pyrex glass 1-l. beakers there were added, respectively, 1 l. of distilled water, 1 l. of distilled water containing 2 g. of inactive potassium carbonate (anhydrous), 1 l. of mixed effluent and 1 l. of mixed effluent containing 2 g. of inactive potassium carbonate. To each of the 8 beakers there was then added 1 ml. of the diluted potassium-42.

It had been planned to monitor the radioactivity in these beakers with a glass Geiger dip counter. However, the counter developed a crack at the start of the experiments and so an improvised technique was used. Aluminum pans, 50 mm. in diameter and 23 mm. in height, were suitably mounted under an Amperex 200-CB halogen-filled end-window counter, which had a window thickness of 1.4 mg. per square centimeter and which was operated at 1,200 v. A conventional scaler was used. Twenty five-ml. portions of the solution from each of the 8 beakers were transferred on four successive days to the aluminum pans and the radioactivity measured. On the first day the counts were taken as soon as possible after the addition of the radioactivity to the beakers and on samples which had been stirred before taking out the portions for counting. On the succeeding days, care was taken

not to stir the contents of the beakers and to use only the clear supernatant liquor for counting. However, after the samples for counting had been taken, the contents of the beakers were again stirred.

Table I presents the radioactivity (in counts per minute) of the contents of each of the beakers corrected for dead time of the counter, for background radiation, for non-linearity and for decay to one common time for the whole series of experiments. The order of counting the samples was randomized. The values for the first day, although self-consistent, are much lower than the values for the three following days. This may be explained only to a minor extent by the added absorption of beta rays due to the presence of suspended solids in the samples for March 17, 1953. The principal reason lies in the uncertainty of the correction for non-linearity. This had been determined by adding to the 25 ml. of water in an aluminum sample pan successive measured increments (25 or 50 lambdas [ml. $\times 10^{-3}$]) of the first dilution of the potassium-42 unit and then measuring the radioactivity. The magnitude of the departure from linearity of the curve for radioactivity versus the increment at a given count was used to corrrect the observed count. The count for March 17, 1953, was much higher than the highest count included in this curve. The correction, therefore, was taken from an extrapolated portion of the curve at a considerable distance from the last experimentally determined point and so was of dubious accuracy. The count for March 18, 1953, was on an extrapolated portion of the curve which was not far from the last experimentally determined point and the counts for March 19, and March 20, 1953, were on the experimentally determined portion of the curve.

A statistical analysis of the data in Table I led to several conclusions. The effluent count (with and without the potassium carbonate) is frequently greater than the corresponding distilled water count in the stainless steel beakers and the contrary is true in the glass beakers. These differences are, however, probably insignificant, so that it may be concluded that the effluent causes no loss of radioactivity. The addition of inactive potassium-carbonate exerts a favorable effect in preventing loss of radioactivity on the containers by adsorption. Contrary to

TABLE I.—Effect of Effluent and Other Factors on Radioactivity

Date 1953	Radioactivity (counts per minute)							
	Samples in Stainless Steel Beakers				Samples in Pyrex Glass Beakers			
	Distilled Water	Distilled Water and K_2CO_3	Mixed Effluent	Mixed Effluent and K_2CO_3	Distilled Water	Distilled Water and K_2CO_3	Mixed Effluent	Mixed Effluent and K_2CO_3
Mar.								
17	31,889	32,100	31,740	32,743	32,526	32,527	32,660	31,500
18	45,033	42,156	41,096	46,166	45,472	47,344	42,481	42,594
19	44,230	45,763	46,200	46,058	45,401	48,598	47,098	47,131
20	45,460	46,515	45,460	47,257	47,217	49,209	46,827	48,741
Totals[1]	134,723	134,434	132,756	139,481	138,090	145,151	136,406	138,466
Summary Totals	269,157		272,237		283,241		274,872	

[1] Excepting Mar. 17, 1953.

what had been expected, the glass vessels seemed to have slightly more radioactivity than the stainless steel vessels. Although the data of March 17, 1953, are not included in the totals given in Table I, on which the statistical conclusions were based, their inclusion in the totals would not seem to alter the conclusions reached.

The possibility of detecting the radioactivity in the basin by means of a portable counter with an unshielded Geiger tube was investigated. At noon on the third day, a counter held above the surface of the beakers indicated a radioactivity of 2 to 3 milliroentgens per hour and on the fourth day there was a small response. This indicated that if the dilution in the basin was no greater than that in the beakers, the radioactivity would be capable of detection above the normal background radiation for two or three days by means of a portable counter.

Determination of Basin Detention Time

First Run

One unit of potassium-42 was transported from the Brookhaven National Laboratories to Bound Brook in the morning. This was estimated to have a radioactivity of about 155 mc. when taken from the reactor. To the radioisotope, which was contained in a small glass vial, 5 ml. of water were added and the mixture was stirred with a long glass rod. Twenty-five lambdas of the solution were removed with a micropipet and added to 950 ml. of water in a bottle. After the solution was mixed, 50 lambdas were added to each of three 1-in. stainless steel planchets and dried under an infrared lamp. These planchets were used to determine the half-life and the range in aluminum of the radioisotope, in order to make sure that there was no error in its identity before introducing it into the settling basin.

The next morning at the effluent basin the dissolved unit of potassium-42 was divided into four parts. Each portion was added to wide-mouth, glass-stoppered jars containing approximately 375 ml. of water to which had previously been added 2 g. of $K_2CO_3 \cdot 1\frac{1}{2}H_2O$. At a given signal the contents of each of the four jars were discharged as quickly as possible to each of four influent ports to the settling basin. An attempt to detect the movement of the radioactivity by monitoring the surface of the basin with a Geiger counter from a boat led to inconclusive results. Also inconclusive were attempts to detect the arrival of radioactivity at the four outlet ports of the settling basin by monitoring the surface of the basin with portable Geiger counters. These attempts were soon discontinued.

Effluent samples were then taken at each of the exit ports at 20-min. intervals, starting approximately 1 hr. after the unit had been added to the basin. Control samples had been taken from the basin about $1\frac{1}{2}$ hr. before the potassium-42 had been added. The samples were collected in 68-mm. diameter by 150-mm. high wide-mouth, glass-stoppered bottles of 325 ml. capacity, with 35-mm. diameter mouths. Each bottle contained 1 g. of $K_2CO_3 \cdot 1\frac{1}{2}H_2O$. The samples were transported to the laboratory and the radioactivity was counted by placing the sample bottle in a shield built of lead bricks but open at the top. A steel-cathode Geiger tube was fixed on a clamp and immersed as far as possible into the bottle. The tube was operated at 900 v. and the counts obtained on a conventional scaler counter.

Figure 1 is a plot of the radioactivity of the samples, corrected for background radiation and for decay to the time at which the first sample was taken, versus the time after addition of radioactivity to the basin. The four successive outlet ports are lettered A, B, C and D. There is some indication of the arrival of radioactivity at the outlets at periods from 1 to 3 hr. after

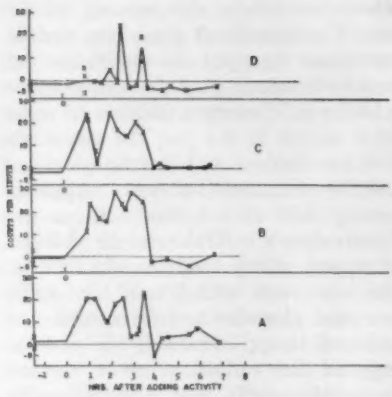


FIGURE 1.—Radioactivity of successive settling basin effluent samples determined on the first run. Letters A, B, C and D denote the outlet ports of the settling basin.

adding the potassium-42. However, the differences between the radioactivities of successive samples, except for Curve B, are so great that it is not possible to get more than a slight indication of the detention time.

Second Run

In order to get a better picture of the detention time, the experiment was repeated with a new unit of potassium-42 having the same radioactivity as the first unit. However, some changes were made in the test procedures. Instead of splitting the unit into four parts, the entire unit was added at the center influent port of the settling basin. No attempt was made to survey the surface of the basin; instead samples were taken at each of the four exit ports at regular intervals of approximately one-half hour, starting at the time the unit of potassium-42 was added. As a control a sample of the basin water had been taken 40 min. before the unit was added. The samples were brought back to the laboratory and counted as described previously. In addition to the samples, blanks occasionally were counted. These consisted of either water or a standard composed of 0.6 ml. of the second dilution of the unit in a bottle containing potassium chloride and distilled water. By counting this standard at intervals during the course of the experiment and correcting for decay, it was possible to check on instrumental errors. None of the values of the standard differed from the mean by as much as twice the standard deviation.

The variation in background radiation, as measured by the dip counter immersed in the water blank during the course of this experiment, is shown in Figure 2. This behavior is unusual and probably indicates the existence of abnormal radioactivity in the air which decreased with time according to the curve. The background radiation values which were applied to the samples were taken from the curve for the time corresponding to that when the sample was counted.

Figure 3 shows the curves for radioactivity (corrected for background radiation, but not decay) versus time at the four exit ports. The vertical lines on each curve represent the 90 per cent confidence limits for each point (or for the weighted average, where the curve is drawn through the weighted average of two or more

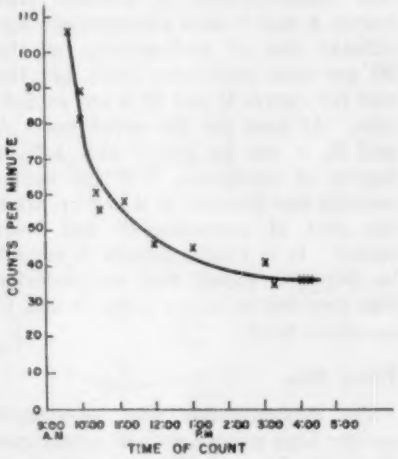


FIGURE 2.—Variation in background radioactivity for the second run.

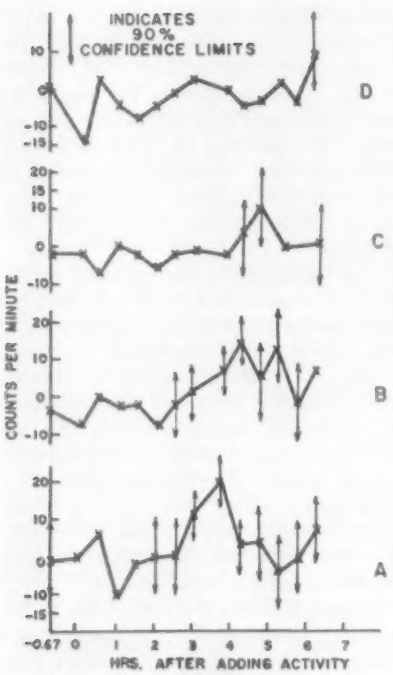


FIGURE 3.—Radioactivity of successive settling basin effluent samples determined on the second run. Letters A, B, C and D denote the outlet ports of the settling basin.

points). Taking the confidence limits into consideration, it appears that curves A and B show a statistically significant rise of radioactivity at the 90 per cent confidence level, but the rise for curves C and D is not as definite. At least for the outlet ports A and B, it can be stated with a high degree of confidence that the radioactivity was detected at 3 to 4 hr. after the unit of potassium-42 had been added. It is likely, though it cannot be definitely stated, that radioactivity was detected at outlet ports D and C sometime later.

Third Run

The determination was repeated 6 months later using a unit of potassium-42 in the form of 13 g. of potassium carbonate with an estimated activity, when taken from the reactor, of 520 mc. The irradiated potassium carbonate came wrapped in aluminum foil in a wide-mouth glass jar contained in a lead pig. Twenty milliliters of water were added to the jar, the aluminum foil was broken with a long glass rod and the mixture was stirred. Approximately 0.16 ml. of this solution was dissolved in a bottle containing 950 ml. of water. Fifty lambdas of this solution were then added to a 1-in. stainless steel planchet and dried under an infrared lamp. The half-life and energy of the radiations were checked as usual, except that a considerably greater amount of radioactivity was taken than previously so that it was possible to obtain adequate identification of the sample in a period of 2 hr. after making up the solution.

The dissolved unit was then transported to the effluent settling basin. Fifty milliliters of water were added to the jar and the dissolved unit was poured quickly at 4:00 PM into the center inflow stream in the settling basin. Samples were taken at the four effluent ports starting at 4:00 PM and at hourly intervals thereafter throughout the night. Each sample bottle had been prepared previously by adding 4 ml. of a solution containing 1 g. of potassium chloride. The walls of the bottles were wetted with this solution and it was thoroughly mixed with the samples at the time they were taken.

The radioactivity of the samples was counted as before. Background radiation counts also were made on distilled water containing 1 g. of potassium chloride. Contrary to what had happened in the previous test run, the background radiation count was constant within the normal statistical variation during the entire counting period.

Potassium chloride was used in place of potassium carbonate in the sample bottles, since it had previously been observed that potassium carbonate

caused precipitation of solids from the effluent, although this probably did no harm. What was wanted was potassium ion to reduce the possible adsorption of radioactivity on the walls of the bottle.

Figures 4 and 5 show the results of this experiment in terms of radioactivity counts, corrected for background radiation but not for decay, versus elapsed hours after adding the potassium-42. The vertical lines represent the 95 per cent confidence range of each point. Statistically significant increases in radioactivity were obtained at each outlet port. The results indicate that at outlet ports B, C and D the radioactivity was first detected between 2 hr. and 3 hr. after it was added. At port A it was observed at between 4 hr. and 5 hr. after being added.

Discussion

The work described in this paper was done with a limited objective. This was to determine, with no more elaboration than was required for the needed information, the time for passage of an increment of effluent from the inlet to the outlet of the settling lagoon. For this purpose, the sampling and measuring techniques, as described for the third run, seem to be adequate, though simple. However, the method is capable, with sufficient elaboration, of providing more than this bare minimum of information. For example, A. Montens (8) has described the use of Geiger-Mueller tubes one meter long connected by cables up to 60 m. in length to the counting apparatus. With this equipment, he was able to get accurate curves of radioactivity in counts per minute versus time. It was then possible to integrate the curve and obtain a measurement of flow-through, which was defined as the time at which one-half of the total number of counts was registered. By using as many as 8 to 10 fixed and moveable counting tubes at various locations and depths, elaborate contour diagrams could be drawn to

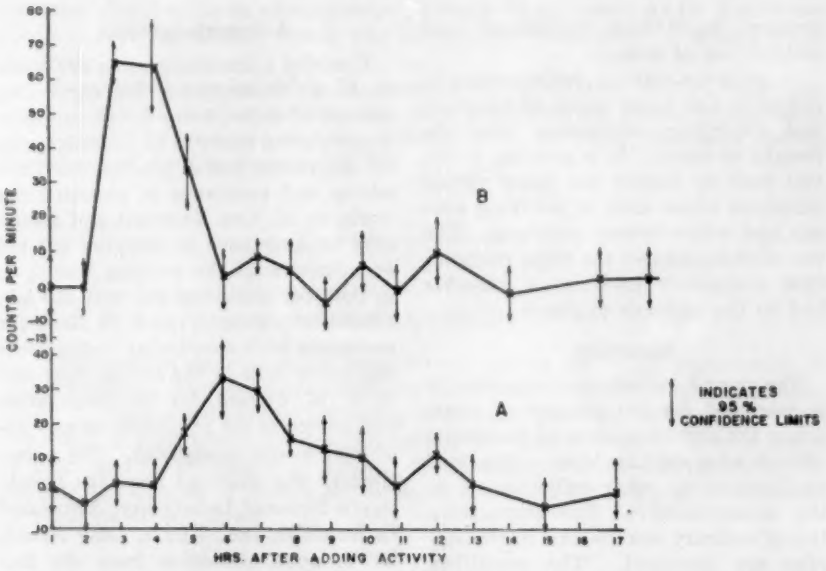


FIGURE 4.—Radioactivity of successive settling basin effluent samples determined on the third run. Letters A and B denote the first two outlet ports of the settling basin.

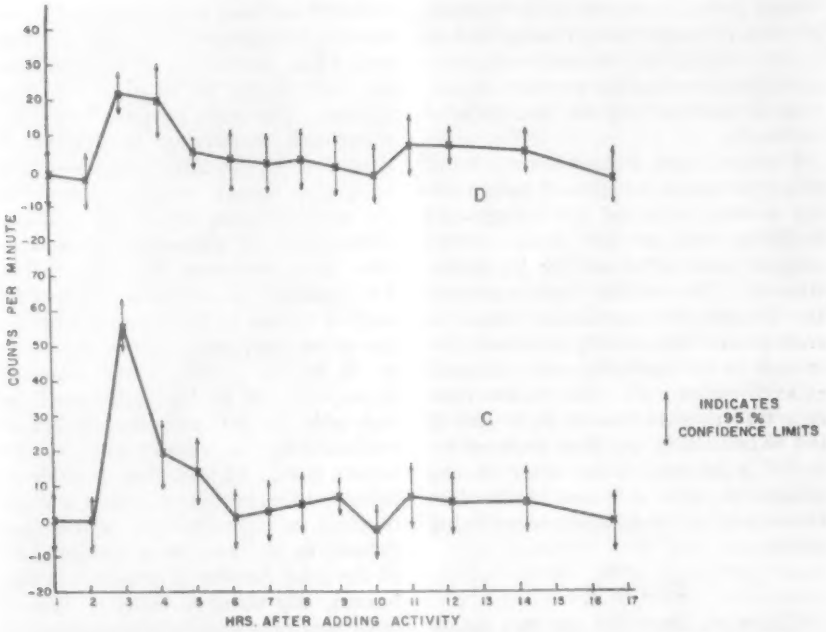


FIGURE 5.—Radioactivity of successive settling basin effluent samples determined on the third run. Letters C and D denote the third and fourth outlet ports of the settling basin.

measure layer flow, turbulence and distribution of sewage.

A great variety of radioisotopes is available and many types of counting and recording equipment may be bought or made. It is possible to devise tests to answer the many varied questions which arise in studying sewage and water system problems. The use of radioisotopes for these purposes thus commends itself as a valuable tool to the sanitary engineer.

Summary

The use of radioactive potassium-42 is described for the purpose of measuring the detention time of industrial effluent in a settling basin. Reported applications of other radioisotopes to the measurement of flow characteristics of sanitary sewage and water supplies are discussed. The versatility and power of these techniques are emphasized.

Acknowledgments

Grateful acknowledgments are made to H. J. Rodenberger for suggesting the use of radiotracers for the application reported here; to L. L. Hedgepeth, W. Rohrhurst and J. MacKay for their advice and assistance in planning the work; to M. Van Nostrand and associates for assistance in carrying out the experiments in the settling basin; to J. Berg for statistical aid with the laboratory experiments; to J. H. Rook for assistance with monitoring instruments and other help in the initial run; and to C. M. Judson for his cooperation and advice in the procurement and use of radiometric equipment. The potassium-42 was obtained from the Brookhaven National Laboratory, Associated Universities, Inc., Upton, Long Island, N. Y. upon allocation from the Isotopes Division of the United States Atomic Energy Commission.

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GRADUATE RESEARCH ASSISTANTSHIPS

The University of Florida, College of Engineering, announces the inauguration of a Ph.D. program in sanitary engineering. Graduate assistantships in research are available for a number of students. Students are allowed 4/5 residence credit while on assistantships paying $133 per month and 2/3 residence credit at $177 per month. Study may be undertaken in either the M.S. or Ph.D. program.

Appointments as assistants in research, with equivalent rank of instructor, are available at salaries greater than those stipulated for graduate assistants.

Further information may be obtained from the Dean, Graduate School, University of Florida, Gainesville, Fla.

SCHOLARSHIPS

Scholarships to encourage high school seniors to study engineering or physical science have been announced by the Armco Foundation of Middletown, Ohio. Sixteen scholarships, providing $650 each year for four years, will be available to high school seniors throughout the United States. Free selection is permitted in the choice of school. Scholarships will be distributed on the basis of the number of Armco employees in a community and are *not* restricted to children of employees.

Stream Pollution

FEDERAL WATER POLLUTION CONTROL LEGISLATION *

By M. D. Hollis and G. E. McCallum

Respectively, Chief Engineer and Chief, Water Supply and Water Pollution Control Program, Public Health Service, Department of Health, Education, and Welfare, Washington, D. C.

This is a particularly interesting time to be working on any aspect of the water situation in this country. The growing attention that is being given to water resources is indicated by the number of commissions, boards and study groups which have been considering various aspects of the problem in recent years. Many of the recommendations resulting from these studies will have a profound bearing on evolving policies for water pollution control.

There are good reasons why the water resources situation in the United States should be undergoing critical re-evaluation at this time. Certainly the total supply of water, in the form of precipitation, far exceeds the country's total needs and, in most places, the readily available sources of water are still enough to meet current demands. However, in quite a few cities, including some large metropolitan areas and a considerable number of smaller towns, the demands have exceeded, or soon will exceed, the readily available supplies. Although scattered, the number of such instances is increasing to an order of magnitude that is of national concern, particularly when viewed in terms of the great industrial and population growths still to come. This problem is, of course, only one aspect of the great technological age in which we now live. As science and new industrial developments continue to advance at an accelerating pace we must expect the water resources problem to become increasingly critical. This is bound to focus more and more public attention on conservation of water through abatement of pollution.

One of the many factors bearing on national water policies is the Public Health Service water pollution control legislation. Any analysis of the legislation now before the Congress would be incomplete, however, without some consideration being given to the national pollution problem, the past program, the need for legislation and the philosophy and intentions of the Public Health Service. The latter are particularly important because the attitudes and intentions of an agency are invariably woven into the legislative history of any Act it is to administer. Furthermore, these expressed intentions influence future interpretations.

USPHS Philosophy

The Public Health Service regards the program being administered by it under the Water Pollution Control Act as comprising simply those Federal activities needed to complement the work of the state and interstate agencies, communities and industries

* Presented at 28th Annual Meeting, Federation of Sewage and Industrial Wastes Assns.; Atlantic City, N. J., Oct. 10–13, 1955.

in order to attain a well-balanced national pollution control program. From the very beginning of its concern with water pollution, dating back about a half-century, the primary function of the Public Health Service has been to provide assistance of various kinds, through state and interstate agencies, to enable communities and industries to be better equipped to solve their own pollution problems.

The Congress has repeatedly made it clear, in its delineation of responsibilities in this field, that water pollution control is a primary responsibility of the States. The Water Pollution Control Act of 1948, under which the Public Health Service is now operating, declares it to be the policy of the Congress "to recognize, preserve, and protect the primary responsibilities and rights of the States." This policy declaration not only is repeated in the legislation now pending in the Congress but is reaffirmed by a further provision that: "Nothing in this Act shall be construed as impairing or in any manner affecting any right or jurisdiction of the States with respect to the waters (including boundary waters) of such States." The Public Health Service supported this amendent when it was proposed in the Senate and desires the legislation be thoroughly consistent with this declaration of policy.

This position of the Public Health Service does not apply only to the problem of water pollution; it is the basic philosophy of the Service with respect to all its numerous cooperative State-Federal programs. In its long history of working with the States, the Public Health Service has found that the best way of getting a job done is to support and assist the States. The more the state-interstate-Federal working partnership can be strengthened, the more effective it will be. The job ahead will be difficult enough, even with the closest collaboration among those principally concerned.

Public Understanding

Better understanding of the problems involved is necessary to engender wider public confidence and greater support. It is not uncommon today to read seemingly informed articles, or even technical reports on water resources, in which the significance of pollution control is entirely overlooked or is given only passing attention. The fact that water, if properly treated, can be used over and over again has a way of getting left out of discussions on water consumption, falling water tables, salt water infiltration, weather control, and so on. Only when the benefits that may be derived from water pollution control are more widely appreciated, will this activity receive the attention it needs.

Public understanding is an especially important consideration in this age of intense competition. Not only must pollution control compete, in both a professional and an economic sense, with other aspects of the water resources problem, but it also must compete for attention and support with other important public needs such as schools and highways which have more general appeal. The taxpayer is immediately conscious of the roads because his car is on them and of the schools because his child brings him into close daily contact with them. By contrast, the water tap at the sink seems a long way from the polluted stream.

In practical terms this means that getting municipal tax dollars for construction of pollution control works, always a difficult task, may become even harder in view of the growing needs and demands for other types of public services. In fact, a number of authorities believe that a new approach to financing pollution abatement works will be needed if the rate of construction is to keep pace with the needs and

a number of new schemes for financing construction of pollution abatement works are now being considered. One proposed approach would involve Federal financial participation along the lines being considered for highway and school construction.

Recent Developments

One of the activities of the Public Health Service program under the existing law has been to collect information on which to determine national needs. This information, compiled in cooperation with the States, provides a basis for planning comprehensive programs for pollution control by major watersheds. These data have been useful in portraying, for the first time, the pollution situation for the country as a whole and what will be needed for its control.

Briefly, the situation in 1955 is this:

1. The existing backlog of needed municipal works, due largely to the virtual stoppage of construction during World War II, amounts to $1.9 billion.
2. The average per capita expenditure for treatment and interceptors today is $2.42 per year.
3. The net pollution loading being discharged to streams by communities amounts to the equivalent, in organic content, of the raw sewage from a population of 55 million. This last fact is most significant.

If the backlog of deferred construction were made up, the population equivalent to streams would be reduced from 55 million to 36 million. To make up the backlog over the next 10 years, and at the same time take care of population growth and treatment plant obsolescense, it would be necessary to about double the average per capita expenditure.

Control of industrial pollution also constitutes a major task. Industry is carrying on extensive pollution control work throughout the country, but there is a great deal still to be done in this field.

The Water Pollution Control Act, originally designed for an exploratory period of five years ending June 30, 1953, was extended for an additional three years to provide more time for consideration of the type of legislation needed to carry on the program. During this period there were numerous consultations on the future direction of the program with state and interstate agencies and with professional organizations concerned with water supply and water pollution control.

In the meantime, the new Robert A. Taft Sanitary Engineering Center at Cincinnati was completed, a significant step in an operation that began in 1913 as the Stream Pollution Investigations Station. This new facility will make possible the development of a major center for research, demonstrations and technical assistance on a wide range of sanitary engineering problems. Water pollution is, of course, a prime concern of the new center. So from the standpoint of facilities and experience, the Public Health Service should be in a position to make greater contributions to water pollution control work in the years ahead.

Pending Legislation

The legislation now pending before Congress to extend and improve the present Act has three main goals:

1. A broadened research program.
2. Increased technical assistance.
3. A five-year program of grants to States and interstate agencies on a matching basis.

From the long-range viewpoint, the provision for a broadened and strengthened research program is no doubt the most significant improvement contemplated in the pending legislation. This provision would authorize the Surgeon General to do the following:

1. Make research grants to public and private agencies, universities and other institutions and to individual investigators.

2. Establish and maintain research fellowships.

3. Enter into contracts with public or private agencies for research, training and demonstrations.

4. Obtain advice and assistance of experts from outside of Government.

Such a program, together with strengthened research activities of the Public Health Service at Cincinnati, should increase research significantly in this field. It should premit a start on the existing large backlog of worthwhile research projects and an expansion of some already under way. Through it, for example, ways may be found to reduce the costs of treating conventional wastes and to develop methods for more effective and economical treatment of atomic and other new wastes that have been making their appearance in recent years. A number of years ago a noted authority stated that far less was known about the composition and biochemical reactions of a stream than was known of the anatomy and functioning of the human body. He added that if more was known about this strange meandering patient sanitary and public health personnel would be better prepared, not only to keep it well, but to treat it properly when sick. This is still true. Further research and investigation into the make-up and behavior of streams is an area to which greater attention must be directed.

When the proposed research program gets under way, the Public Health Service technical assistance program should also be expanded and improved to meet requests more fully. Such assistance may not be needed frequently in any one state, of course, but, when an unusual problem does occur, there should be means for readily applying all available information. The Sanitary Engineering Center, when fully staffed and equipped, should be able to fulfill this need.

The pending legislation retains the provision that the Surgeon General encourage the formation of interstate pollution control agencies and the adoption of improved state water pollution control laws. A provision authorizing the Public Health Service, upon the request of a state or interstate agency, to conduct investigations and make surveys concerning specific water pollution problems is likewise retained.

Under the pending legislation, the Public Health Service would continue to have the advice and assistance of a Water Pollution Control Advisory Board, and the membership of the board would be broadened. The Surgeon General's stand-by enforcement authority would also be continued, to be used on interstate situations only when the States or interstate agencies concerned have been unable to deal successfully with the problem at hand and want such assistance. That this enforcement authority would remain on a "last-resort" basis was made clear in both the Senate and House Committee reports on the pending legislation and has been repeatedly reaffirmed in the past. It is probable, with the closer working relationships which are being achieved, that enforcement action would seldom, if ever, be necessary. On the other hand, it is generally agreed that such a mechanism needs to be available to provide relief when all other corrective efforts have been exhausted.

The important provision in the proposed legislation for matching grants to state and interstate water pollution control agencies deserves some comment. Naturally, the need for such assistance varies considerably from state to state and from region to region, depending on the extent of the pollution problem, population and other factors. The strengthening of

state and interstate programs, which is the purpose of this provision, not only benefits the states and regions themselves but is of real benefit to the whole country.

Conclusions

The main points of the legislation now under consideration have been briefly touched upon. This legislation appears to the authors to be consistent with the basic principles of the present law. The increased emphasis on research, the provision for matching grants, and other changes would, however, bring the legislation more closely into line with present and anticipated needs.

As all those in this field so well know, pollution control is a complex business. The problems involved are economic, scientific, social and Nationwide. Of these, the matter of costs will probably remain the most troublesome. Serious water pollution conditions do not come about overnight; they usually develop over a long period of time. Solving the many difficult problems involved in instituting corrective measures also takes time. Then, once the technical and other problems have been worked out, the financial outlays are often of shock proportions. Not infrequently, the sums involved lead to consideration of inadequate facilities or prolonged inaction. The number of such cases occurring throughout the country again points to the need for an intensive search for more effective and economical methods of treatment.

The matter of economic justification of pollution control measures surely will become an increasingly important consideration. The Public Health Service is beginning to look into this matter and also to relate the problem of pollution control more closely to the whole broad question of water supply. It is generally agreed that economic losses resulting from water pollution and the benefits that may be derived from its control need more intensive analysis.

The accomplishments which have been made in the complex field of water pollution control are surely a tribute to the professions engaged in this work. More than that, they are an assurance that the same kind of ingenuity and perseverance will be applied to the difficult problems that lie ahead.

NEW DIRECTOR OF BDSA

Louis F. Frazza, executive of the Johns-Manville Sales Corp., was appointed on March 14, 1956 as Director, Water and Sewerage Industry and Utilities Division, Business and Defense Services Administration, U. S. Department of Commerce. Under the rotation system, outstanding business executives serve the Government without compensation for periods of six months or longer. He succeeds Harry F. Bower, official of James B. Clow and Sons, Chicago, who has served since July, 1955.

Mr. Frazza is a registered professional engineer and has held offices in several professional engineering societies. In addition, he is an active member of the New Jersey Sewage and Industrial Wastes Association and the American Water Works Association.

NATURAL SEDIMENT AS A FACTOR IN STREAM POLLUTION CONTROL *

By Richard D. Hoak and Henry C. Bramer

Mellon Institute, Pittsburgh, Pa.

Industrial wastes, domestic sewage, and nature usually are cited as the principal factors in stream pollution. Discussions of stream pollution, however, generally ignore the magnitude of nature's contribution to the unsatisfactory condition of large stretches of surface water. Attention is properly directed to industrial and municipal waste waters, because these discharges are responsible for extensive pollution, and because their effects can be controlled by regulation. The pollutional effects of natural processes are not ordinarily subject to control, but they should be taken into account when water quality criteria are adopted.

Natural Contamination

Nature affects the use of water in various ways, as a few examples will illustrate. Fluoridation of public water supplies has been front-page news in recent years because of its proved effectiveness in reducing the development of dental caries in children. As the fluoride concentration of water rises above the optimum of 1 p.p.m., however, the hazard of mottled enamel increases. The weighted average concentration of fluoride ion in some western rivers ranges up to 1.7 p.p.m. and individual samples have contained as much as 7.0 p.p.m.

A very small amount of boron is essential to plant growth, but above an optimal value it becomes toxic. Plants vary in sensitivity to boron. Some are damaged by concentrations greater than 0.5 p.p.m. while others can tolerate up to several parts per million. The weighted average concentrations of boron in western rivers varies from 1.1 to 3.2 p.p.m.

Compounds of fluorine and boron are leached from rocks by rainfall. The concentration of dissolved salts limits the use of water for irrigation. The salt content of irrigation water increases as a result of transpiration and evaporation, and water which drains from such land has a marked effect on the dissolved solids content of many western rivers. Although this is a somewhat indirect natural process, it is worth noting that the weighted average concentration of dissolved solids in these rivers ranges up to 4,580 p.p.m., with individual samples containing up to 13,000 p.p.m. (1)(2).

Many natural streams contain colored substances leached from vegetation. The concentration of coloring matter is sometimes as high as several hundred parts per million. Excessive algal growths cause difficult water purification problems, especially in control of tastes and odors. The mechanism through which algal blooms develop is poorly understood, but in a few areas they seem to result from discharge of waste water. Most tastes and odors in drinking water occur naturally through decay of vegetation, but industrial wastes are sometimes responsible (3).

Erosion of soil by rainfall carries suspended matters to streams. This material impedes the photosynthetic

* Presented at 28th Annual Meeting, Federation of Sewage and Industrial Wastes Assns.; Atlantic City, N. J.; Oct. 10–13, 1955.

action of sunlight; it destroys fish spawning grounds; it smothers benthic life; and it can interefere with navigation. Many industrial wastes also carry inorganic materials in suspension, and there has been a tendency to limit discharge of such material without regard to the load of suspended matter in the receiving water.

It is the purpose of this paper to describe a method for estimating the amount of suspended solids in streams as a function of their flow rates, and to show how this factor can be used to prescribe proper limitations upon discharge of similar material in waste water.

Preliminary Study of Data

The raw water used in industrial operations sometimes carries a heavy load of natural silt. If this water picks up an appreciable amount of suspended matter in an industrial plant, *e.g.*, in washing blast furnace gas, it normally is settled in clarifiers before discharge to the streams. Under some conditions the clarifiers operate at more than 100 per cent efficiency, *i.e.*, their effluents contain less suspended matter than the raw water intake. Use of industrial waste treatment facilities to improve surface water by removing natural substances cannot be justified, but imposition of arbitrary, numerical limitations may actually require this. If the purpose of pollution control is to protect streams from the effects of waste water, regulations must be carefully drawn to achieve this entirely proper aim. If local conditions are taken into account in fixing limitations upon discharge of various substances, blanket regulations applicable to large areas will not properly serve their purpose.

The question of appropriate limitations upon discharge of suspended solids to the Monongahela and Ohio rivers arose in the course of a broad survey of the subject. Since practical limitations would depend on the amount of natural suspended matter normally present in the rivers, all available data were examined.

The Army Engineers Corps and the United States Geological Survey collected relatively small sets of samples at various points from 1930 to 1950. It was apparent that these observed values could not simply be averaged to estimate mean loads, because proper weight could not be given to the effects of runoff from rainfall, temperature, time of year and other factors. Prediction of sediment loads therefore had to be related to a variable whose behavior was known rather precisely. Stream discharge rates provided such a variable, because accurate records of these rates have been kept for a long time.

The data showed some correlation between discharge rate and concentration of suspended solids, but high confidence could not be placed upon it. On the other hand, the correlation between discharge rates and loads was very good. Loads of suspended solids versus discharge rates are plotted in Figure 1 for three points on the Ohio river. Plots for other points were quite similar. This correlation suggested that the relationship between load and discharge rate could be used predictively. In view of the small number of observations and the short periods covered on the Monongahela and the Ohio rivers, it seemed preferable to apply the technique first to another stream for which more data were available. The desired data were collected in a study made on the Delaware River by the Geological Survey.

Delaware River Data

Concentrations and sediment loads on the Delaware River at Trenton, N. J. were recorded daily for the water year October 1, 1949 to September 30, 1950. Frequency distributions of data for concentrations, sediment loads and discharge rates showed that these quantities are distributed log-normally.

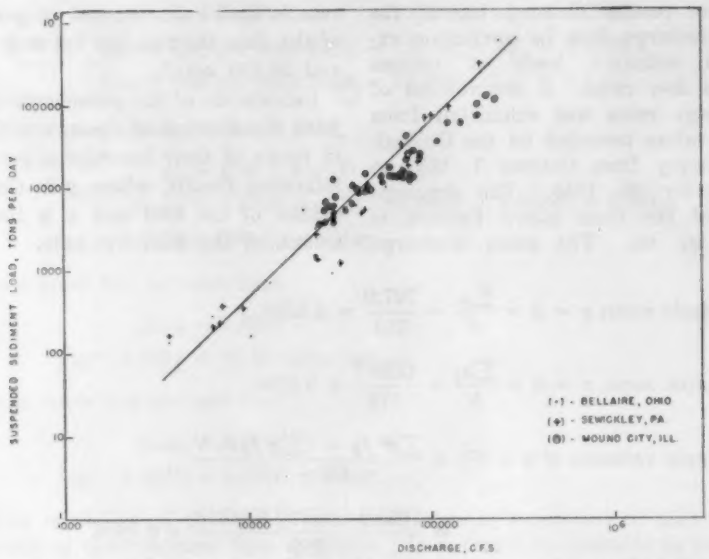

FIGURE 1.—Comparison of suspended solids load with discharge rate in the Ohio River.

Concentrations and loads versus discharge rates are plotted in Figures 2 and 3, respectively. It seems apparent from these plottings that the relationship between load and discharge rates is the closer of the two. This was checked by calculating correlation coefficients, using logarithms of the observed values to satisfy the distribution requirement. The results are shown in Table I.

TABLE I.—Correlation Coefficients: Delaware River

Variable Set	Coefficient	95 Per Cent Confidence
Concentration, discharge	0.417	0.37–0.50
Load, discharge	0.822	0.78–0.85

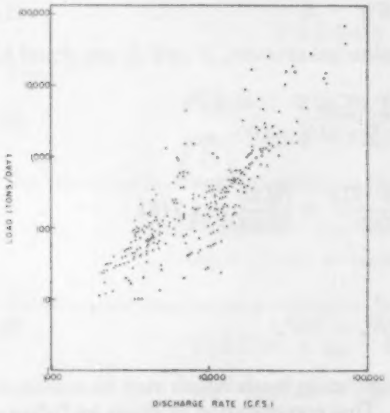

FIGURE 2.—Tons suspended solids *vs.* discharge rate, Delaware River, Trenton, N. J.

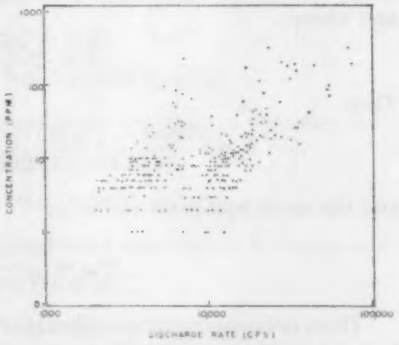

FIGURE 3.—Suspended solids (p.p.m.) *vs.* discharge rate, Delaware River, Trenton, N. J.

These results dictated use of the load-discharge data in computing expected sediment loads at various stream flow rates. A distribution of discharge rates was calculated from daily values recorded by the Geological Survey from October 1, 1938 to September 30, 1948. The drainage area of the river above Trenton is 6,796 sq. mi. The mean discharge rate is 12,270 sec.-ft., and 90 per cent of the time the rate lies between 2,158 and 34,290 sec.-ft.

Calculation of the parameters of the joint distribution of the two variables in terms of their logarithms gave the following results, where y is the logarithm of the load and x is the logarithm of the discharge rate.

$$\text{Sample mean } y = \bar{y} = \frac{\sum y_i}{N} = \frac{727.9}{313} = 2.3256$$

$$\text{Sample mean } x = \bar{x} = \frac{\sum x_i}{N} = \frac{1229.7}{313} = 3.9288$$

$$\text{Sample variance of } y = S^2_y = \frac{\sum y^2 fy - (\sum y\, fy)^2/N}{(N-1)}$$

$$= \frac{1845.9 - (727.9)^2/313}{312} = 0.4906$$

$$\text{Sample variance of } x = S^2_x = \frac{\sum x^2 fx - (\sum x\, fx)^2/N}{(N-1)}$$

$$= \frac{4866.3 - (1229.7)^2/313}{312} = 0.1126$$

$$\text{Standard deviation of } y = S_y = \sqrt{S^2_y} = 0.7004$$

$$\text{Standard deviation of } x = S_x = \sqrt{S^2_x} = 0.3355$$

The regression equation is:

$$\mu_{y.x} = A + B(x - \bar{x}) \tag{1}$$

where the unbiased estimates of the regression parameters, A and B, are $\bar{y}$ and b, and where

$$b = \frac{\sum xy - \sum x \sum y/N}{\sum x^2 - (\sum x)^2/N} \tag{2}$$

Then

$$b = \frac{2920.0 - (1229.7)(727.9)/313}{4866.3 - (1229.7)^2/313} = \frac{60.25}{35.13} = 1.7151$$

and the mean square deviation is:

$$S^2_{xy} = \frac{N-1}{N-2}(S^2_y - b^2 S^2_x) \tag{3}$$

These parameters permit calculation of the mean loads which may be expected to correspond to various discharge rates. This computation is given as follows for the mean discharge rate and for the rates which enclose the 90-per cent interval about the mean rate.

Mean discharge rate = 12,270; log. = 4.0890
Lower five per cent limit = 2,158; log. = 3.3338
Upper five per cent limit = 34,290; log. = 4.5352

For the mean discharge rate:

$$\bar{y}_x = \bar{y} + b(x - \bar{x})$$
$$\bar{y}_{12270} = 2.3256 + 1.7151(4.0890 - 3.9288) = 2.6004$$
$$\log.^{-1} 2.6004 = 398.5 \text{ tons/day}$$

For the lower five per cent limit:

$$\bar{y}_{2158} = 1.3051$$
$$\log.^{-1} 1.3051 = 20.68 \text{ tons/day}$$

For the upper five per cent limit:

$$\bar{y}_{34290} = 3.3656$$
$$\log.^{-1} 3.3656 = 2{,}320 \text{ tons/day}$$

The reliability of the above estimated loads is dependent in part on the quantity of observational data available. It is therefore desirable to establish the degree of confidence which may be placed upon them. A confidence interval may be placed about the estimated loads as follows:

$$\bar{y}_x + t_{0.5\alpha} S_{yx} \sqrt{\frac{1}{N} + \frac{(x - \bar{x})^2}{(N-1)S^2_x}} < \mu_{yx} < \bar{y}_x + t_{1-0.5\alpha} S_{yx} \sqrt{\frac{1}{N} + \frac{(x - \bar{x})^2}{(N-1)S^2_x}} \quad (4)$$

This expression gives the $100(1 - \alpha)$ per cent confidence interval for the mean y corresponding to a given x. For the mean load corresponding to the mean discharge rate ($\alpha = 0.05$):

$$P\left[2.6004 - 1.97(0.3999)\sqrt{\frac{1}{313} + \frac{(.1602)^2}{312(.1126)}} < \mu_{yx} < 2.6004 + 1.97(0.3999)\sqrt{\frac{1}{313} + \frac{(.1602)^2}{312(.1126)}}\right] = 0.95$$

Then

$$P[2.5510 < \mu_{yx} < 2.6498] = 0.95$$
$$\log.^{-1} 2.5510 = 355.7; \quad \log.^{-1} 2.6498 = 446.5$$

For the mean load corresponding to the lower five per cent limit of discharge rates:

$$P[1.2143 < \mu_{yx} < 1.3959] = 0.95$$
$$\log.^{-1} 1.2143 = 16.38; \quad \log.^{-1} 1.3959 = 24.88$$

For the mean load corresponding to the upper five per cent limit of discharge rates:

$$P[3.2736 < \mu_{yx} < 3.4576] = 0.95$$
$$\log.^{-1} 3.2736 = 1{,}878; \quad \log.^{-1} 3.4576 = 2{,}868$$

The confidence intervals computed above apply only to the means of sets of data. A confidence interval can be placed about an estimate of a particular

load at any given flow rate as follows:

$$\bar{y}_x + t_{0.5\alpha} S_{yx} \sqrt{1 + \frac{1}{N} + \frac{(x - \bar{x})^2}{(N-1)S^2_x}} < y$$

$$< \bar{y}_x + t_{1-0.5\alpha} S_{yx} \sqrt{1 + \frac{1}{N} + \frac{(x - \bar{x})^2}{(N-1)S^2_x}} \quad (5)$$

This interval gives the $100(1 - \alpha)$ per cent confidence interval for prediction of the load corresponding to a given discharge rate.

For the load corresponding to the mean discharge rate:

$$P[1.8110 < y < 3.3898] = 0.95$$

$$\log.^{-1} 1.8110 = 64.73; \quad \log.^{-1} 3.3898 = 2{,}454$$

For the load corresponding to the lower five per cent of discharge rates:

$$P[0.5126 < y < 2.0976] = 0.95$$

$$\log.^{-1} 0.5126 = 3.26; \quad \log.^{-1} 2.0976 = 125.2$$

For the load corresponding to the upper five per cent of discharge rates:

$$P[2.5723 < y < 4.1589] = 0.95$$

$$\log.^{-1} 2.5723 = 373.5; \quad \log.^{-1} 4.1589 = 14{,}420$$

These estimated loads and confidence intervals are plotted against discharge rates in Figure 4. The central solid line represents the estimated mean loads, and the pair of lines closest to it inclose their confidence interval. The outermost pair of lines gives the confidence interval for predicting a particular load at a given discharge rate. Estimates of sediment loads in terms of discharge rates can be read from the curves in Figure 4, but this chart applies only to the Delaware River at Trenton. Similar charts can be constructed for other points, but the spread of the confidence intervals will depend upon the quantity of data available.

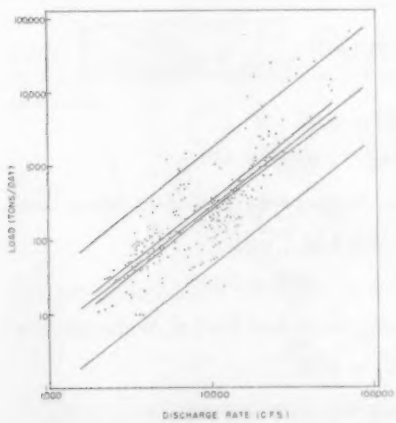

FIGURE 4.—Estimated load and confidence limit of suspended solids *vs.* discharge rate, Delaware River, Trenton, N. J.

Ohio River Basin Data

Suspended sediment data for the Ohio River basin were analyzed by the procedure used for the Delaware River. These data comprised sets of 4 to 27 observations taken at eight stations on the Allegheny, Monongahela and Ohio rivers from June 20, 1942 to July 17, 1946, and one set of 51 observations taken at one station on the Ohio River from September 11, 1930 to February 27, 1931. These data were rather scanty as compared with those for the Delaware River.

Loads, concentrations and discharge rates were found to be distributed log-normally. Correlation coefficients for loads versus discharge rates were computed, using logarithms of the vari-

TABLE II.—Correlation Coefficients: Ohio River Basin

Station	No. Observations	Coefficients	95 Per Cent Confidence
Monongahela R. at Braddock, Pa.	14	0.948	0.83 to 0.97
Allegheny R. at Natrona, Pa.	14	0.971	0.90 to 0.98
Ohio R. at			
Sewickley, Pa.	19	0.962	0.90 to 0.99
Bellaire, Ohio	10	0.955	0.80 to 0.97
Huntington, W. Va.	5	0.799	−0.22 to 0.97
Cincinnati, Ohio	10	0.798	0.33 to 0.94
Evansville, Ind.	4	0.834	−0.45 to 0.98
Metropolis Ill.	27	0.693	0.40 to 0.84
Mound City, Ill.	51	0.892	0.82 to 0.94

ables. The close relationship between loads and flow rates is shown in Table II.

Distributions of discharge rates were made from observations covering a 10-year period for each of the sampling points. Drainage areas, mean flow rates and their 90 per cent ranges are given in Table III.

The mean loads corresponding to the mean, and to the upper and lower five per cent limits of discharge rates were calculated, together with the 95 per cent confidence interval about each mean. These data are tabulated in Table IV.

The reliability of the procedure for predicting sediment loads can be illustrated by comparing the mean loads estimated at Metropolis, Ill. and Mound City, Ill. The original data at Metropolis were collected between June 27, 1942 and February 19, 1946; those at Mound City between September 11, 1930 and February 27, 1931. The close agreement of predicted loads, using data collected a dozen years apart, for two sampling points separated by only 29 miles on a large river, is good evidence that the method yields dependable results.

Predicted mean loads are plotted against drainage areas in Figure 5. Loads are shown for the upper, mean, and lower flow rates. The vertical lines represent the confidence intervals for each of the computed loads. Confidence intervals for predicted loads are plotted against discharge rates in Figure 6. These data plottings show clearly the relationship between area, flow rate and sediment load. They

TABLE III.—Flow Rates: Ohio River Basin

Station	Drainage (sq. mi.)	Discharge Rate (c.f.s.)		
		5 Per Cent	Mean	95 Per Cent
Braddock, Pa.	7,337	1,815	13,000	38,890
Natrona, Pa.	11,410	1,749	19,080	63,040
Sewickley, Pa.	19,500	3,694	31,290	97,750
Bellaire, Ohio	25,170	6,008	38,890	121,400
Huntington, W. Va.	55,900	10,230	79,850	244,400
Cincinnati, Ohio	76,580	13,920	109,270	334,940
Evansville, Ind.	107,000	19,350	152,540	468,120
Metropolis, Ill.	203,000	36,470	289,100	888,400
Mound City, Ill.	203,600	36,580	289,950	891,030

TABLE IV.—Sediment Loads: Ohio River Basin

Station	Mean Load (tons/day)					
	5 Per Cent		Mean		95 Per Cent	
Braddock, Pa.	67.7	31.1 —* 147.3	1,924	1,304 — 2,839	12,400	6,868 — 22,380
Natrona, Pa.	54.7	37.4 — 80.1	1,648	1,119 — 2,422	9,014	6,188 — 13,130
Sewickley, Pa	77.0	44.2 — 134.1	4,339	3,168 — 5,945	37,220	23,800 — 58,230
Bellaire, Ohio	200.8	90.5 — 456.4	7,168	2,267 — 21,150	63,780	23,080 — 176,400
Huntington, W. Va.	562.8	82.6 — 3,832	12,490	5,209 — 30,000	84,520	32,120 — 222,600
Cincinnati, Ohio	3,773	208.4 — 68,330	54,980	15,380 — 196,800	235,800	144,300 — 384,900
Evansville, Ind.	224.0	150.8 — 332.5	58,970	38,260 — 84,340	1,218,000	820,600 — 1,809,000
Metropolis, Ill.	10,590	2,660 — 42,160	157,900	116,800 — 213,800	683,000	421,900 — 1,106,000
Mound City, Ill.	7,292	6,298 — 8,442	128,600	82,240 — 201,000	703,700	393,400 — 1,023,000

* The 95 per cent confidence interval for each mean load is shown by the pair of values separated by a line at the right of the mean load values.

also indicate that, in this region, sediment load is primarily a function of discharge rate, rather than of drainage basin characteristics. The physical nature of the Ohio River drainage basin varies widely, ranging from intensive cultivation to dense forest cover.

Empirical Equations

Simple empirical equations can be written to express the relationship between sediment load and discharge rate for the Ohio and Delaware river basins. For loads in tons per day and discharge rates in cubic feet per second, these equations are:

Ohio River:

$$\text{Load} = 1.301 \times 10^{-4} (\text{Discharge Rate})^{1.688} \quad (6)$$

Delaware River:

$$\text{Load} = 3.83 \times 10^{-5} (\text{Discharge Rate})^{1.718} \quad (7)$$

Equations of this kind can be used to predict sediment loads for drainage

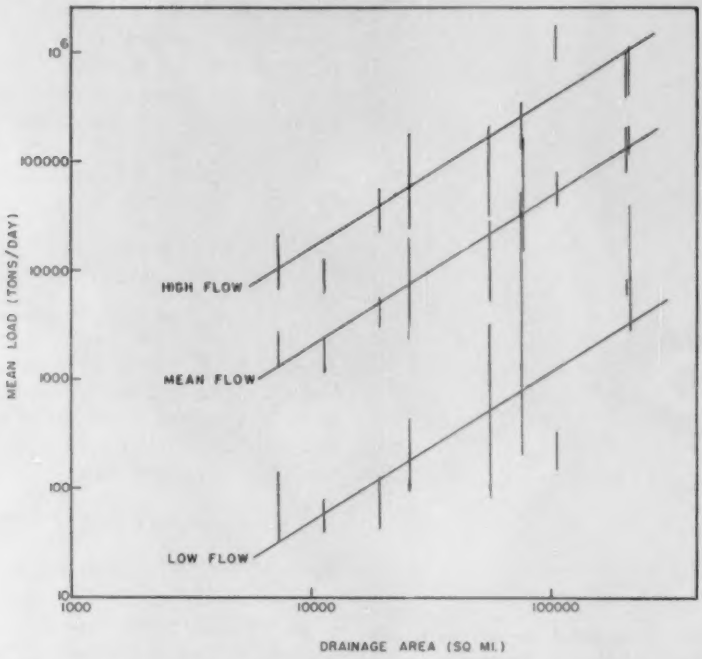

FIGURE 5.—Predicted mean load suspended solids *vs.* drainage area, Ohio River basin.

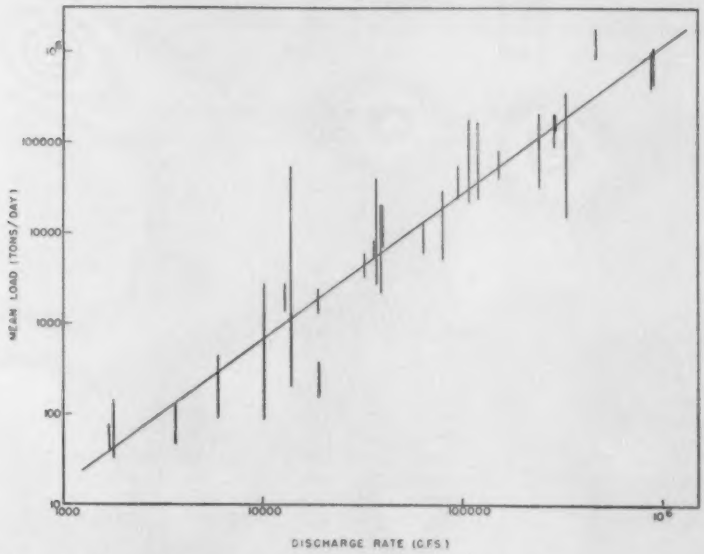

FIGURE 6.—Confidence intervals for predicted loads. *vs.* discharge rate, mean suspended solids, Ohio River basin.

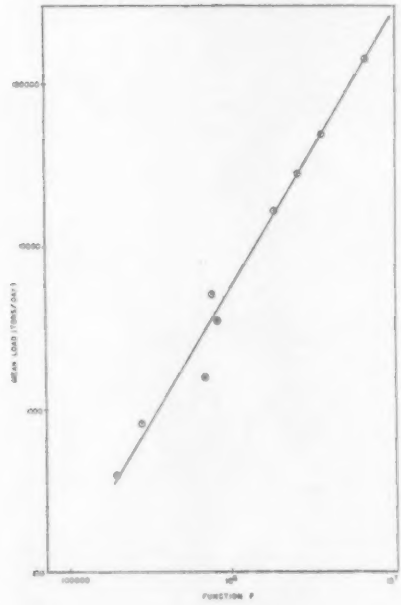

FIGURE 7.—Relationship of mean suspended solids to function *F*.

areas which do not differ greatly from those found in the Ohio and Delaware river basins. There is reason to expect that mean sediment loads are a function of the degree of variation of discharge rates, as well as of the mean rate. It may be postulated that the mean load of suspended solids will be a function of the ratio of the upper and lower five per cent limits of flow rate, multiplied by the mean rate. That is:

$$F = \frac{\text{Upper five per cent rate}}{\text{Lower five per cent rate}} \times \text{Mean discharge rate}$$

A plot of F versus mean sediment loads is shown in Figure 7, and it may be seen that the relationship of the two variables is fairly good. The equation of the line in Figure 7 is:

$$\text{Load} = 8.17 \times 10^{-7} \times F^{1.656} \quad (8)$$

Table V lists the values for F, mean sediment loads calculated from Eqs. 6, 7, and 8, and mean loads determined by conventional statistical methods.

It may be seen that agreement among the several estimates is fairly good, and that the larger the number of observations the better the agreement. Comparison of this table with

TABLE V.—Comparison of Estimates of Loads

Station	F	Mean Load (tons/day)			Observations (no.)
		Eqs. 6, 7	Eq. 8	Statistic	
Monongahela R. at Braddock, Pa.	278,000	837	685	1,924	14
Allegheny R. at Natrona, Pa.	690,000	1,580	3,050	1,648	14
Ohio R. at					
Sewickley, Pa.	830,000	3,583	4,100	4,339	19
Bellaire, Ohio	775,000	5,133	3,650	7,168	10
Huntington, W. Va.	1,900,000	16,980	16,000	12,490	5
Cincinnati, Ohio	2,640,000	28,400	28,000	54,980	10
Evansville, Ind.	3,690,000	49,260	49,000	58,970	4
Metropolis, Ill.	7,040,000	142,000	142,000	157,900	27
Mound City, Ill.	7,050,000	142,000	142,000	128,600	51
Delaware R. at Trenton, N. J.	197,000	397	380	397	313

Table IV shows that, with one exception (Natrona), empirical estimates of loads fall within the confidence intervals about each of the statistical mean loads.

Natural Sediment in Practice

Natural sediment may be a significant factor in evaluating the performance of equipment for removal of suspended matter from waste water. The operation of a modern mechanical clarifier for recovery of dust from a blast furnace gas washer was studied over a four-month period. Table VI lists the concentrations of suspended solids in the clarifier influent and effluent, and the net discharge from the clarifier.

The data in Table VI illustrates the importance of taking proper account of natural sediment in raw water supplies. The averages show a net discharge roughly one-half as great as the amount attributed to the clarifier. River turbidities were relatively low during the survey period; had they been higher the discrepancy probably would have been even larger.

TABLE VI.—Effect of Natural Sediment on Clarifier Performance

Susp. Solids, Intake Water (p.p.m.)	Susp. Solids, Clarifier Effl. (p.p.m.)	Net Discharge, Clarifier Effl. (p.p.m.)
40	79	39
52	129	77
96	107	11
97	81	−16
60	127	67
40	105	65
36	91	55
28	147	119
11	85	74
10	71	61
12	75	63
17	101	84
24	80	56
35	115	80
10	107	97
5	124	119
11	97	86
31	89	58
67	92	25
28	113	85
28	93	65
19	78	59
214	97	−117
115	70	−45
96	215	29
Av. 47.3	99.1	51.8

These results from operation of an actual clarifier point to the desirability of relating limitations upon discharge of suspended inorganic solids to the load of such material carried by the receiving stream. Figures 5 and 6 show that suspended sediment in streams is cumulative with respect to drainage area and flow rate, and that most of it is carried to the ocean. If this were not so, it is evident that stream channels would soon fill up with deposited sediment.

Summary

Three methods are presented for estimating the load of suspended solids in streams. The method to be used will depend on the quantity and quality of available data, the location for which the information is desired, the accuracy required and the time allowed to get the information.

Where there are no data on suspended solids and the characteristics of the drainage areas do not differ greatly from those in the Ohio and Delaware river basins, Eq. 8 may be used to estimate sediment loads. If the location is in the Ohio River or the Delaware River basin, Eqs. 6 or 7 may be used. Where actual load data are available, the full statistical method should be used to make precise estimates.

An example is given to illustrate the effect of natural sediment on clarifier operation. It is proposed that regulations governing discharge of suspended inorganic solids be related to the normal load of such material carried by the receiving stream.

Acknowledgment

This paper is a contribution from the Multiple Industrial Fellowship which has been sustained at Mellon Institute since 1938 by the American Iron and Steel Institute.

The courtesy of District Engineers of the Army Engineers Corps in supplying unpublished data on sediment loads, and of the United States Geological Survey in providing copies of Water Supply Papers, is gratefully acknowledged.

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DISPOSAL OF RADIOACTIVE WASTES TO PUBLIC SEWERS

The Atomic Energy Commission has approved a proposed regulation establishing standards for protection of personnel and the public against radiation hazards. The standards are based on recommendations made by the National Committee on Radiation Protection.

The standards applicable to the disposal of radioactive wastes to public sewers follow.

Section 20.33 Disposal into Public Sewers

(a) Except as authorized in paragraph (b) of this section, or in Section 20.34, no licensee shall release, discharge or dispose of licensed material into a public sewer except as specifically authorized by the Commission in writing.

(b) Licensed material may be discharged into public sewers provided that: (1) the material is in a form readily soluble in water; and (2) for each million gallons of sewage effluent in which the dilution is expected to occur, the amount of radioactive materials discharged shall not exceed one millicurie [1] of Strontium 90 or Polonium 210; 100 millicuries of Iodine 131, or Phosphorus 32 or any radioactive material having a half life less than 30 days; or 10 millicuries of other radioactive material.

Section 20.34 Disposal by Dilution with Stable Isotopes of the Same Element

Any licensed material which has been diluted and homogeneously mixed with stable isotopes of the same element in the same chemical form to the extent that the dose rate within such material, as so diluted and homogeneously mixed, does not exceed 300 millirems per week, may be disposed of by burial in soil, in the ocean or into public sewers without regard to the requirements of Section 20.33 (or those sections regulating burial in soil or the ocean).

The regulations include an appendix setting forth the maximum permissible average concentrations of radioactive materials in air and water. Copies of the complete regulations are available from: United States Atomic Energy Commission, Washington 25, D. C.

[1] A millicurie means that amount of radioactive material which disintegrates at the rate of 37,000,000 atoms per second. Remember that the effects of radiation are accumulative.

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SLUDGE DISPOSAL PRACTICES IN THE PACIFIC NORTHWEST *

BY ROBERT E. LEAVER

Senior Public Health Engineer, Washington State Department of Health, Seattle, Wash.

The disposal of sludge from a sewage treatment plant receives operator comment whether the plant is large or small. Disposal methods vary from the small treatment plant with an annual drying of sludge on the drying beds to the large treatment facility located on the seacoast, where sludge is barged to sea in special tankers. The sludge disposed of may be raw or digested; a liquid or a dried solid. When digested its public health significance is less critical and, when properly treated, dried sludge is as safe to handle as a commercial fertilizer.

At the majority of sewage treatment plants sludge disposal is a problem to some degree and it is a necessary operating expense at all treatment facilities. Methods of sludge disposal and the financial burden entailed were studied for several municipalities in the Pacific Northwest, principally in the state of Washington.

Comparative Value of Fertilizers

To better understand the problem involved in the disposal of sludge it is well to consider the fertilizer value of available organic fertilizers and their cost. The fertilizing ingredients in sewage sludges, various manures and organic nitrogenous material are presented in Table I. Digested sludge, in general, is about equivalent in fertilizing value to manure. In Seattle, Wash., manure costs approximately $6.50 per yard or $16.60 per ton, based on a dry weight of 1,300 lb. per yard and a 60 per cent moisture content. Humus sells for $2.00 per yard when picked up at the pit, or approximately $5.10 per ton on a dry weight basis. The heat dried activated sludge, Milorganite, sells for $4.55 in 80 lb. sacks or the equivalent of $114 per ton, dry weight. The major portion of this cost is due to transportation charges. The Milorganite returns $33.64 per ton, wholesale, at the treatment plant in Milwaukee, Wis.

Sludge Disposal Methods

The principal methods of digested sludge disposal in the state of Washington and adjacent states utilize sludge drying beds, tank trucks, vacuum filters and lagooning. The heat drying of sludge is not generally practiced nor are there any installations incinerating the sludge as a method of disposal. Most of the sludge

* Presented at the 1955 Annual Meeting, Pacific Northwest Sewage and Industrial Wastes Assn.; Victoria, B. C.; Oct. 27–29, 1955.

TABLE I.—Fertilizing Ingredients in Sewage Sludges, Various Manures and Organic Nitrogenous Materials

Material	Fertilizing Ingredient[1] (%)			
	Nitrogen (N)	Phosphoric Acid	Potash	Organic Matter
Digested settled sludge	0.8–3.5	0.7–4.0[2]	—	—
Digested settled sludge with trickling filter sludge	1.0–4.5	tr.–4.0[2]	0.8–1.6[2]	30–60[3,4]
Digested activated sludge	2.0–4.8	1.0–3.6[2]	—	—
Heat dried-activated sludge	4.0–7.0	1.7–2.5	0.13	—
Commercial pulverized				
Sheep manure	1.2–2.5	1.0–2.0	2.0–4.0	48
Cattle manure	1.6–2.1	1.0	1.0–2.2	66
Poultry manure	1.9–4.0	2.5–3.7	0.8–1.3	64
Animal tankage	5–10	7–16	—	—
Blood	9–13	0.5–14	—	—
Fish scrap	6.5–10	5–10	—	—
Cottonseed meal	5–8	2–3	1–2	—
Castor pomace	5–6	2	1	—

[1] See ref. 1.
[2] Dry basis.
[3] Estimated from other tables.
[4] Volatile matter.

is given away to anyone who will haul it from the drying or dump area.

Liquid Sludge

Liquid digested sludge is usually removed from the sewage treatment plant by private contractor or municipal tank truck. The following examples are typical of current practice.

Olympia, Wash., population 17,000, has a contract with a nurseryman and receives approximately $4.80 per ton on a dry weight basis. The contractor gets the liquid digested sludge at the treatment plant in his own tank truck for $2.00 per 1,000 gal. load. The contract requires that the nurseryman take the total annual production of sludge as it becomes digested (less than 40 per cent volatile solids). The contractor apparently is well pleased with the arrangement and the results he gets from spreading the sludge on land used for growing shrubs and other nursery stock. A five-mile round trip is necessary.

Chehalis, Wash., population 5,630, took bids for the period May 1, 1953 to May 1, 1954 on the hauling of digested sludge. The award was made to a contractor who submitted a bid of $400 per year. The wet sludge is picked up at the treatment plant and the contractor must meet all requirements of the state health department. Approximately 142,000 gal. of sludge with a 7 per cent total solids content and 35 to 50 per cent volatile solids were used in 1954, primarily for hay crops. The revenue received averages approximately $10 per ton on a dry weight basis.

Issaquah, Wash., population 1,200, has an arrangement with a local farmer for hauling liquid digested sludge as it becomes digested. Approximately 15,000 gal. of thin sludge is disposed of every six weeks. The farmer makes no charge for hauling nor does the city receive any revenue. In less than one year the hay fields receiving the sludge have improved crop production from poor to excellent.

Shelton, Wash., population 5,250, has hauled liquid digested sludge in a city-owned truck only once since the treatment plant was placed in operation in 1951. Although there are no

sludge drying beds available, the digester has had ample storage capacity and private haulers have taken most of the available sludge.

Air-Dried Digested Sludge

Drying of digested sludge on drying beds has been an accepted method of dewatering sludge for many years. The problem of disposing of the dried sludge still remains, and today the cost is increased due to the steady rise in labor costs.

Typical methods of disposing of air-dried sludge at three sewage treatment plants follow.

Vancouver, Wash., using glass-covered drying beds, produces a well-dried digested sludge which is ground and sold in 80 lb. sacks. The product is marketed under a trade name, and sold for $2.50 per sack. Some bulk sales are made and the city uses some sludge on the parks and other municipal property.

Receipts from sludge sales have been as follows:

1953	$1,593.50
1954	920.63
1955 (7 mo.)	837.92

The cost of processing is carried as operating overhead and is difficult to calculate. Supervisory personnel are of the opinion that the income pays for extra labor, sacks and other handling charges.

Centralia, Wash., grinds and sacks a portion of the sludge dried on open drying beds. Some sludge is sold in bulk quantity and there is no charge for sludge removed directly from the beds by those interested in hauling it away.

Because of the relatively small quantity of sludge sold ($344.06 worth in 1954 and $351.00 worth in 1955), the financial return probably would not pay for the extra labor and sacks. City officials, however, believe the excellent public relations resulting from having sacked sludge available to the citizens has been well worth the expense.

Seattle, Wash. (Diagonal Way Plant) disposes of its air-dried digested sludge to other departments of the municipality for use on public property. The sludge is removed from the beds at no cost to the treatment plant operating fund.

Filter Dried Sludge

Raw and digested sludge both may be dried on vacuum filters prior to disposal. The examples cited, however, filter only digested sludge. Sludge that is sold usually must be air dried or stock piled before being hauled away.

Kirkland, Wash., population 5,500, sells digested sludge on a sliding scale of $3 to $5 per cubic yard depending on the quantity purchased. Receipts vary from $6 to $22 per ton on a dry-weight basis. Filtering costs average $6.25 per cubic yard for chemicals, labor and maintenance, but not including amortization of filter equipment. On a ton basis the cost is $24.

Enumclaw, Wash., population 2,900, sells 100 lb. sacks of air-dried, digested and filtered sludge for $1.50. It is estimated that income just about pays for the cost of chemicals, exclusive of labor and amortization.

Tacoma, Wash., population 100,000, makes no effort to sell the filtered sludge. Filtration costs, not including amortization, average $11.18 per ton.

Lagoon Disposal

Where cheap land is available adjacent to the treatment facilities the lagooning of digested sludge is an economical method. The time eventually arrives when either the sludge must be removed or new lagoons constructed. Two municipalities report as follows on their sludge lagooning operations.

Portland, Oregon, has no sludge drying beds, consequently the digested sludge is lagooned in an area adjacent

to the treatment plant. No serious problems have been encountered with this method since the sludge averages 33 per cent volatile solids and 10 per cent total solids.

Sufficient area is available for several more years of lagooning before more area or another disposal method will be necessary. Sludge in the lagoon measures 2 to 3 ft. in depth at present. Several small drying beds permit the drying of sludge for use on the plant grounds.

Tacoma, Wash., has been lagooning digested sludge in a low area adjacent to the treatment plant to save filter operation costs. The digested sludge averages 12 per cent solids and 40 to 50 per cent volatile matter. Lagooning has not resulted in any serious problems and has saved considerable money. Following a newspaper story on the availability and value of sludge, the public took a considerable quantity of dried sludge from the lagoon.

General

In the state of Washington, disposal of liquid sludge from the digester to a single contractor has been the most successful method from a financial standpoint. Where this method can be done with a minimum of health hazard it certainly can be encouraged. To date, there has not been a reported record of any health problem in the state of Washington resulting from the use of digested sludge. It is true that liquid digested sludge is theoretically dangerous since it could contain pathogenic organisms.

Practically all sewage treatment plants serving populations of fewer than 10,000 people use open drying beds and make no serious attempt to sell sludge. Usually the dried sludge is given away or used on municipal property. To date, sludge disposal has not been a serious financial problem and little effort has gone into developing a market. With some promotional activity and understanding of the agricultural needs, undoubtedly sufficient revenues could be obtained to make disposal financially profitable.

Legal Implications

In connection with prescribing the limitations and procedure regarding the use of sludge, the Washington State Health Department has in the past taken the position that the return of digested sludge to the soil should be encouraged, provided a low degree of health hazard can be maintained in the particular method of operation.

The Rules and Regulations of the Washington State Department of Health, Sec. 11, Part 3, Book V, reads as follows:

"Section 11. *Use of Sewage Sludge for Fertilizer.* The use of sewage sludge for fertilizing material shall be in compliance with the limitations and procedures as may be prescribed by the State Director of Health;* and the owner shall notify the State Director of Health of an intended use of sludge as a fertilizing material."

The Washington State Attorney General's Office on June 2, 1949, rendered the following opinion concerning the liability of a city arising from the use for fertilizer of sludge from a city sewage treatment plant.

"The city stands in the position of manufacturer of the sludge. Normally, a manufacturer is not liable to persons other than the buyer who may be injured by his product unless he is guilty of negligence, deceit or breach of warranty. In the case of inherently dangerous articles such as explosives, unwholesome foods, poisons, and possibly untreated or semi-treated sewage, a manufacturer may be liable if he fails to give adequate warning of the nature of the product.

"Even assuming that the sludge is classified as an inherently dangerous product, putting the highest degree of care on the manufacturer, it is our opinion that a city would not be liable for damages resulting from the use of sludge if each contract

* See Appendix I.

of sale contained a sufficient warning of the possible dangerous nature of the sludge and the necessity of securing the approval of the Department of Health before using the sludge as a fertilizer. A clause similar to the following would be appropriate:

"'The buyer understands that sludge purchased under this contract may be dangerously unfit for use as fertilizer and that the use of sludge for fertilizer is subject to the approval of the State Director of Health according to Section 11, Part 3, Book V of the Rules and Regulations of the State Board of Health. The seller makes no warranties or representations as to the condition or fitness for any purpose of the sludge.'

"Alternatively, non-liability may be secured by having all sludge inspected at the plant and selling only approved sludge for fertilizer."

The State of Washington has a basic Fertilizer Act, Chapter 15.54 Revised Code of Washington (1953) administered by the State Department of Agriculture, which requires registration and a fee of $25 for each brand name and sets up definitions of various fertilizers, agricultural minerals and limes, etc., and provides certain labeling requirements. The act would cover the sale of sludge if it is processed in any way, but if it is air dried and handled like manure, the present policy has been to consider it as such and as manure, registration is not necessary.

Reference

1. "Utilization of Sewage Sludge as Fertilizer." Manual of Practice No. 2, Federation of Sewage Works Assns., Champaign, Ill. (1946).

APPENDIX I.—GENERAL GUIDE FOR THE UTILIZATION AND DISPOSAL OF SEWAGE SLUDGE. WASHINGTON STATE DEPARTMENT OF HEALTH

It is the intent of the Washington State Department of Health in determining the limitations and procedure for the utilization of sewage sludge to encourage the beneficial use of such sludge so that the disposal by treatment works will not become an unnecessary financial burden, provided, however, that a low degree of health hazard can be obtained in the particular method of operation.

In evaluating and setting up specific limitations and procedure in any intended use of sludge, consideration will be given to the quality of operation, as reflected in the operation reports, design capacity and field inspections.

Methods of Disposal

Raw Sludge

The use of raw sludge (undigested) as a fertilizing material in any form is not permitted. Septic tank sludge would normally be considered as raw sludge. Raw sludge may be disposed of by proper burial.

Improperly Digested Sludge

Sludge that has not been properly digested, or a mixture of raw and digested sludge should be considered as raw sludge.

Digested Sludge—General Conditions

With the exception of proper heat-dried sludge, all digested sludge used as a fertilizer shall be disposed of in such a manner that the purchaser or user has read and signed a statement that he or she understands the following, or a statement is provided with each lot of sludge which reads substantially as follows:

"The buyer or user of this material understands that it is digested sewage sludge and should not be used on root crops, or low growing vegetables, fruits and berries, which are used for human consumption. The seller or furnisher makes no warranties or representation

as to the condition or fitness of the sludge for any purpose.

"Persons finding it necessary to handle this material should immediately following wash their hands carefully with soap and hot water."

Digested Sludge—Specific Conditions

1. Liquid sludge may be discharged at the site of the sewage treatment plant; under pressure below ground in orchards, hop fields and other crop land where there is no danger of contaminating low growing crops or berries, or leaching out on to the ground surface; or on fenced hay fields provided cattle are excluded for a period of 45 days. The treatment plant operator must maintain complete records on the use of the sludge. Handling of the sludge must be done in a sanitary manner.

2. Air-dried sludge must be dried for at least 30 days or until it can be handled with a pitchfork. Use on root crops, or low growing vegetables or fruits is permitted if the sludge is applied and plowed under six months prior to planting. Stock-piling the sludge several months prior to use in landscaping work is recommended. Air-dried sludge having a moisture content of less than 10 per cent may be sacked and sold to the general public provided the statement given under *"Digested Sludge—General Conditions"* appears on the bag.

3. Vacuum filtered sludge that has been stock-piled for 30 days subsequent to filtering, may be considered as air-dried sludge.

4. Heat-dried sludge which has been properly dried can be used generally, without special restrictions.

CORROSION IN SEWAGE WORKS *

By Edwin R. Stowell

Senior Sanitary Engineer, California State Division of Architecture, Sacramento, Calif.

Negligence in the control of corrosion frequently has been due to a lack of knowledge in understanding the corrosion factor. Specific instances may be observed where abnormal or excessive deterioration of plant structures or equipment has occurred, due primarily to corrosion. In many cases this has taken place without the operating personnel recognizing that corrosion was active.

It is not anticipated or expected that all sewage treatment plant operators will become corrosion experts. However, it is the obligation and duty of all operating personnel to detect and report excessive wear or deterioration of treatment facilities intrusted to their care, no matter what the cause of the deterioration.

In support of the premise that the role of corrosion may be overlooked in the wear of equipment, a section of sludge scraper chain was removed from a primary clarifier. Inspection revealed that one side of the chain had been worn or corroded to a thin knife-edge section, while the other side had retained its original cross section. This rather familiar "wear" pattern of scraper chains is considered by many operators to be due solely to mechanical wear. The condition, however, is largely a result of corrosion forces, possibly in combination with erosion or mechanical wear, whereby new metal is constantly being exposed to corrosion. The important point is not that this excessive and localized loss

* Presented at 1955 Annual Meeting, California Sewage and Industrial Wastes Assn.; Riverside, Calif.; April 27–30, 1955.

of metal occurred, but rather that the operator did not observe or consider anything unusual in the wear. That is, he did not recognize the corrosion factor. This chain was found on the scrap metal pile with no report whatsoever of any unusual wear having taken place.

Examples of Corrosion

Corrosion is not always so readily noticed. In some forms of corrosion, the original shape and form of the material is retained despite severe corrosion. A section of cast iron drain line was obtained after clogging of the line had been reported, due supposedly to soap and greases. From an observation of the deposits in the pipe, it was apparent that the clogging was primarily due to corrosion products. Portions of the pipe section revealed shiny metal while other parts were black and dull. In the black, dull areas the metal had been completely corroded from the iron-graphite material leaving only the graphite. This graphite has little structural strength and can be easily cut with a knife. This is graphitization, a form of corrosion associated with gray cast iron.

The yellow brasses have a similar specific type of corrosion called dezincification. In material failures due to dezincification, the zinc is corroded from the brass leaving only the copper portion of the zinc-copper alloy. This is readily detected by filing as the copper color of the dezincified area sharply contrasts with the yellow brass color of the alloy. The dezincified metal has little strength or resistance to wear and the result is failure.

Idle equipment often is neglected and damaged by corrosion. Frequently such corrosion is greater than if the equipment was in use. Equipment that is operated normally presents conditions less favorable to the condensation of moisture and the accumulation of moisture retaining corrosion products. Variations in temperature cause an expansion and contraction of air expelling the warm air during warm periods and drawing in cold air as cooling occurs. This may result in the condensation of moisture from the air on internal parts of equipment and their subsequent corrosion. This is particularly true of equipment installed out of doors. A good example of this condition might be evidenced by sewage pumps that have been installed for some time, but have not been finally connected or operated. The solenoid oiler reservoirs were actually full of water inside the glass enclosures due to condensation of moisture from the air.

Other examples of corrosion damage which have been noted include corrosion of aluminum pump frames, comminutor drums and cutters, motor bearings and the rusting and pitting of exposed metal. Damage to concrete, due to septic sewage conditions; the blackening of paint caused by hydrogen sulfide fumes; the rusting of electrical switching enclosures, due to high relative humidity; the corrosion of sludge scraper blades and similar items are indicative of the relentless toll in damage and costs attributed to corrosion factors. Quite often excessive deterioration of wearing parts is due principally to corrosion, because the semi-protective corrosion products are constantly removed, thereby exposing bare metal.

In general, it may be said that where any abnormal or excessive deterioration occurs, corrosion is a possibility. Rusting, pitting, tubercules, discoloration of metal or an adjacent structure, the thinning of metal or similar visual evidence are the most obvious means of detecting corrosion. Certain specific conditions are usually necessary before corrosion will occur. A knowledge of these conditions is perhaps the best means for detecting corrosion before damage occurs.

Conditions for Corrosion

At normal temperatures, moisture is necessary for corrosion. Therefore, damp humid locations or enclosures where condensation occurs should be given careful attention. Listed among these enclosures are automatic bar screens, electrical panel boards, sewage lift stations, wet pits, ventilating stacks and housed areas through which sewage flows. Submerged equipment and structures also are prone to corrosion.

Oxygen is also necessary for continued corrosion, except when low pH conditions prevail. Therefore, greater possibilities for corrosion may exist following oxidation type treatment processes.

Different metals which are in contact with sewage or the soil act as an electric battery, resulting in electrolysis. The extent of this corrosion depends on various factors including the metals involved and the relative areas exposed. If the exposed area of the more corrosive metal is small in relation to the less corrosive noble metal, the corrosion is apt to be severe.

Differences in the environment of a metal also may result in electrolysis. Differences in velocities of flow, dissolved solids or liquids may be among the many environmental conditions which can cause corrosion due to electrolysis. Variations in oxygen content of a liquid produces a particularly corrosive situation. For example, the upper portion of the water seal of a floating gas holder contains more oxygen than the lower portion. Corrosive conditions exist along the line of contact between the water containing oxygen and that devoid of oxygen.

Other conditions favorable to corrosion include increased temperatures, unequal stresses, increased flow velocities, bacterial action, crevices, acid conditions and stray electric currents. In fact any condition creating differences in the environment or causing the removal of protective corrosion products will favor corrosion.

Sometimes the solution is quite simple and economical, such as removing a cover to provide ventilation and thus prevent condensation. Even the placing of an electric light bulb in a switchboard to prevent condensation is a simple and effective remedy. In other instances, the elimination of a given corrosion condition may be quite complicated and in some instances may not be justified economically.

PUMPING GRIT AND SLUDGE*

By Paul M. Thayer

District Manager, Chicago Pump Company, Milwaukee, Wis.

In any discussion of pumps, consideration must be given to all conditions of the installation. The correct pump improperly located or with improper piping cannot operate successfully.

Somewhat similar pumping problems must be considered when pumping either grit or sludge since both materials have a relatively high solids content and may be quite abrasive.

Grit Pumps

Many grit tanks are equipped with mechanisms that rake or convey the grit from the grit tank to an elevated point of discharge where it can be

* Presented at 1955 Annual Meeting, Ohio Sewage and Industrial Wastes Treatment Conf.; Columbus, Ohio; June 22–24, 1955.

dumped into a truck, wheelbarrow, or other conveyance. These tanks do not require a pump for handling grit regularly, but they may require a pump for dewatering purposes. For such service a standard non-clog pump should prove adequate. Occasionally the grit tanks are designed or located so that mechanical devices will not remove the grit and other methods must be employed. In large treatment plants, particularly where a high lift is required, the use of a clam-shell bucket (Figure 1) with a traveling crane or a jib crane appears to give the most satisfactory service.

Air Lift

A simple device that is satisfactory for grit pumping in many of the smaller installations is the air lift. The discharge pipe should be not less than 3 in. in diameter, and there should not be any restriction in the piping. The submergence, the lift above the water surface, and the air volume and pressure must all be properly proportioned to produce a minimum velocity of 3 ft. per second. In those cases involving a lift greater than the submergence of the air lift, a two-stage air lift can be used.

Water Jets

Water jets have also been used for removing grit from grit tanks. Unfortunately these units usually have been unsatisfactory, primarily because of the nature of the water jet itself. To impart a satisfactory velocity to the water it is necessary to utilize the nozzle principle, which is a restriction in the throat of the eductor pipe. This restriction causes frequent plugging of the jet by the large particles that usually are present in grit.

Other Units

Centrifugal or plunger pumps should not be used regularly for handling grit. As an emergency operation or for dewatering grit tanks, any standard type of sewage pump that has the proper capacity and head characteristics will do; but for routine operation some other method of removing the grit must be utilized.

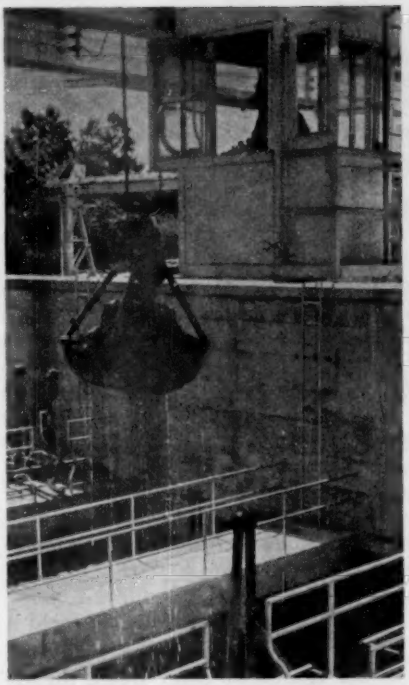


FIGURE 1.—Grit removal with clam shell bucket.

Sludge Pumps

Sludge pumps can be classified according to the service performed. The principal services are:

1. Pumping primary settled sludge to the digester.
2. Pumping secondary settled sludge to the aeration tank in an activated sludge plant.
3. Pumping waste activated sludge to the primary tank.
4. Pumping digester sludge to sludge drying beds or to vacuum filters. Recirculation of digester contents for mixing or heating in an external sludge heater also come under this classification.

5. Pumping the sludge from humus tank (secondary clarifier) to the primary tank or digester.

Frequently one pump may be required to perform more than one type of service, and it must have the proper characteristics for each service. Of the foregoing types of service, that of handling raw or primary sludge presents the most difficult problems. Raw sludge, by its very nature, always contains much solid and other foreign material; also, its consistency varies widely from treatment plant to treatment plant and even from hour to hour in any particular plant. The solids concentration may vary from a minimum of 2 per cent to a maximum of 14 per cent. Both the pumping head and the discharge rate may vary widely, due to operating considerations.

Plunger Pumps

The particular application in the sewage treatment plant would dictate whether centrifugal or plunger type sludge pumps should be used. Plunger pumps always should be used where a suction lift is required with a moderately high total pumping head. They should never be used where there is a high suction head and a fairly low total head. If either the suction line or discharge line is long, air chambers should be installed to cushion the hydraulic shock. Provision is usually made for varying the plunger pump capacity by varying either the speed of the motor or the piston stroke, or both.

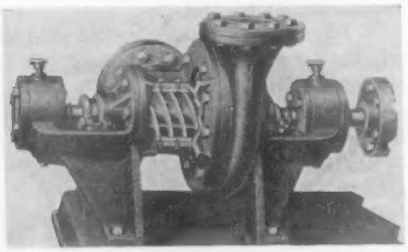


FIGURE 2.—Sludge pump of the "Scru-Peller" type.

Plunger type pumps have the following advantages:

1. Satisfactory operation with a suction lift.
2. Pump at low rates.
3. Deliver a constant volume at varying heads.

Conversely the disadvantages are:

1. Both messy and noisy to operate and maintain.
2. Has small capacity and large space requirements.
3. High maintenance cost.

Centrifugal Pumps

Centrifugal pumps should be used for raw sludge pumping only when there is a positive suction head. The suction line should be as short as possible with a minimum of fittings. Ordinary non-clog centrifugal pumps are occasionally used for sludge pumping; however, considerable clogging is experienced due to rags and debris becoming entangled with the impeller. There are specially designed centrifugal pumps, such as the "Scru-Peller" pump (Figure 2), that incorporate special cutting devices to cut up rags or ordinary debris that enter the pump housing.

Variable Drive

It is important that a pump handling raw sludge be equipped to vary the capacity while still being able to pump against a great differential of head. This can be accomplished best by a variable motor drive. A variable drive with a constant speed motor may be used or the motor speed may be varied.

The proper control and return of activated sludge is one of the most important functions in the operation of an activated sludge treatment plant. The withdrawal of sludge from each hopper of the final settling tanks

should be individually and visually controllable. Pumps for this purpose should be capable of operating at various capacities. Heavy duty, horizontal non-clog pumps, equipped with vari-drive motors, are best suited for this service. They should have water seals to prevent sludge working into the packing glands.

Digester sludge generally is similar to activated sludge, so that heavy duty, non-clog pumps are used. The increased use of external sludge heaters for heating the digester is one of the reasons for the increase in digester sludge pumping in treatment plants of newer design. In this service it has been customary to circulate a constant volume of sludge. Although constant speed pumps usually have been employed, it might be better to use pumps with vari-drives because the friction head is constant, and it is often desirable to vary the sludge flow rate.

Other Pump Considerations

Pumps frequently are installed in digesters for other purposes, such as transferring sludge from one digester to another or to drying beds, vacuum filters, or tank wagons. In any case, the ability to vary the capacity and head independently is an important and worthwhile feature.

The sludge from the final settling tank is similar to activated sludge. It can be handled by a heavy duty, non-clog pump if there is a suction head. When there is a suction lift or a long suction line, then a plunger pump should be used.

Considerable emphasis has been placed on heavy duty non-clog pumps. These pumps should be designed with ample mechanical strength in shafting, bearings, casings, etc., so that deflection of shafting due to unbalanced loading will not cause undue wear and excessive maintenance.

INTERESTING EXTRACTS FROM OPERATION REPORTS

"No business or plan is going very far unless there is teamwork."—*H. K. Harris*

Attention operators! It will be appreciated if copies of all annual reports of both large and small plants are sent to the Federation office for abstracting in this section of the Journal. Carbon copies of typewritten reports will be promptly returned on request. Please direct annual reports to: Federation of Sewage and Industrial Wastes Associations, 4435 Wisconsin Ave., N.W., Washington 16, D. C.

Annual Operation Report of the Niles, Mich., Sewage Treatment Plant for the Year Ended July 31, 1954*

By Charles V. Clem, *Superintendent*

Sewage flow increased an average of 0.5 m.g.d. over the preceding year. Some of the flow increase was attributed to increased rainfall (2 in.). This was the fifth year of operation for this primary treatment plant. Normal reduction of suspended solids and B.O.D. were obtained.

Operating activities were mostly routine, with the exception of cleaning 321,000 gal. of supernatant liquor, sludge and sand from one of the two digesters.† This difficult task required 16 days, using the sludge pump and a

* For last previous extract see This Journal, 26, 2, 230 (Feb., 1954).

† *Editor's Note*—While the use of an enzyme compound the previous year did aid in liquifying some of the digester solids it did not solve the operating problem.

portable piston pump. The solids were packed to within 8 ft. of the digester top and were solid enough to support the weight of a man. Hosing was necessary to loosen the solids which then were pumped to an adjacent field.

The digester was refilled with seed sludge from the other digester and raw sewage. Gas production soon returned to normal.

During the four-month chlorinating season 11,791 lb. of chlorine were used to maintain an average residual of 0.53 p.p.m. in the effluent.

Table II is a summary of operating data for the report year.

TABLE II.—Summary of Operating Data for the Niles, Mich., Sewage Treatment Plant for the Fiscal Year Ended July 31, 1954

Item	Average	Item	Average
Rainfall, total (in.)	37.28	Volatile solids (%)	44.0
Population served (est.)	14,000	Volatile solids, dry (lb. per day)	915
Sewage treated (m.g.d.)	2.3	Supernatant liquor:	
Grit, est. (cu. ft. per m.g.)	0.16	Amount (g.p.d.)	6,090
Total solids (p.p.m.):		Total solids (%)	0.30
Raw sewage	860	Volatile solids (%)	48.0
Effluent	545	Digested sludge:	
Reduction (%)	35	To beds, total (gal.)	178,700
Suspended solids (p.p.m.):		Total solids (%)	12.0
Raw sewage	250	Total solids, dry (lb.)	166,310
Effluent	77	Volatile solids (%)	54.0
Reduction (%)	65	Volatile solids, dry (lb.)	93,000
Settleable solids (ml. per l.):		Gas production:	
Raw sewage	5.2	Cu. ft. per day	10,650
Effluent	0.33	Cu. ft. per lb. volatile solids	15.1
Reduction (%)	89	Cu. ft. per capita per day	0.76
B.O.D. (p.p.m.):		Chlorine:	
Raw sewage	106	Used (lb. per day)	98
Effluent	45	Residual, effluent (p.p.m.)	0.53
Reduction (%)	52	Oper. and maint. cost ($):	
Raw sludge:		Total	57,630.04
Amount (g.p.d.)	4,600	Per m.g.	67.58
Total solids (%)	5.2	Per capita	41.17
Dry solids (lb. per day)	2,020		

REDUCING TEXTILE WASTE PROBLEMS USING STARCH SUBSTITUTES*

By Joseph A. McCarthy

Chief, Lawrence Experiment Station, Lawrence, Mass.

The wastes from textile industries have long been a major source of stream pollution. They have been widely studied in many parts of the country and are under almost continuous investigation at the Lawrence Experiment Station. While much has been said and written about the waste treatment problems arising from such processes as wool scouring, preparing raw cotton for manufacture, and the processing of synthetic fibers, comparatively little attention has been devoted to another very important component of the textile pollutional load, namely the various starches used in the textile manufacturing processes. Yet in many plants the starch contribution to the effluent may cause more

* From the article, "Effects of Starch Substitutes on Textile Wastes." *Sanitalk*, 4, 1, 23 (Nov., 1955).

stream pollution problems than all other factors combined.

Use of Starch in Textile Manufacturing

Starches are used for many purposes in a textile manufacturing plant. They are used in sizing gray goods (the partially finished cloth sent to finishing plants for final processing) and in warp sizing (which is the addition of starch to fibers, especially yarn fibers). They are also used to facilitate weaving and certain other processes and to protect the materials from damage. The amount of starch used varies considerably, depending on the type of fabric and the machinery or methods employed. It may be as much as 24 per cent of the weight of the textile material and is rarely less than 7 per cent, with 10 to 15 per cent coming close to average use. With such proportions it is easy to see why even a medium-size plant may use millions of pounds of starch each year.

Practically all of this starch must be removed from the fabrics in the later stages of processing. In some cases it is necessary to remove some or all of the original starch and then to replace or supplement it by using additional starch, or "add-on." This too must eventually be removed. It is always difficult to obtain the desired degree of removal, especially from tight-woven fabrics. Fairly drastic methods are sometimes employed such as prolonged soaking in water at elevated temperatures, the use of "sour" or acid baths, and protracted holding in hot baths containing specialized enzymes. All of these processes tend toward conversion of the starch into sugars, which makes it possible for the bacteria in streams to utilize the starch for food.

Varieties of starches are manufactured from many original sources and a great many of these have been, and are being, used in textile plants. By far the most important, however, are the corn and potato starches. Most mills prepare starches for use by dissolving them in concentrations of about 0.1 per cent by weight in clean water at temperatures fairly close to boiling and maintaining the solution in tanks kept at this high temperature. The tanks are often equipped with recirculation pumps to keep the solutions at fairly constant temperature and concentration. Samples of such solutions were obtained from several mills and 5-day B.O.D. determinations showed a range between 600 p.p.m. and a little over 1,000 p.p.m. Various starches were also obtained, some of them from actual mill supplies. From these, solutions with concentrations of 0.1 per cent were prepared, simulating as closely as possible actual plant methods of preparation. The five-day B.O.D. values of these solutions varied from 645 to 945 p.p.m. In general, the solutions from potato starch had less B.O.D. than those from corn starch. One of the highest B.O.D. values was obtained from a starch which was apparently a mixture of corn starch, potato starch and a third unidentified material.

Starch Substitutes

It has been suggested by various investigators, including those at the Lawrence Experiment Station, that a considerable reduction in the pollutional load could be made by the substitution, in whole or in part, of materials low in B.O.D. for those normally having a higher demand. It seemed worthwhile to consider possible substitutes for starch.

There are several starch substitutes now on the market, more or less freely available. Those include carboxymethylcellulose (CMC), hydroxymethylcellulose, carboxymethylated starch, several polymers with acryl, vinyl or styrene bases, and a number of other substances identified only as "warp sizes" or by proprietary names. Samples of several of these were obtained

and appropriate solutions prepared, in most cases with the same concentration of 0.1 per cent. The B.O.D. of these was determined using sewage seed, pH adjustment if necessary, and fortification with nitrogen and phosphorous. Some of the results obtained are tabulated in Table I.

In nearly all instances the B.O.D. was very much lower in the mixtures containing starch substitutes than in equivalent starch solutions. Mixtures of solutions prepared from starch and CMC in various proportions (from 65 per cent CMC and 35 per cent starch to 20 per cent CMC and 80 per cent starch) showed the following results:

1. At one day the B.O.D. value equaled 20 to 23 per cent of the calculated value for the starch alone.
2. At two days the B.O.D. value was 72 to 90 per cent of the calculated value for the starch alone.
3. At three days the B.O.D. value was 89 to 95 per cent of the calculated value for the starch alone.
4. At four to five days the mixtures showed B.O.D. values equal to that of the starch alone.

These results indicate that the CMC in intimate mixture tends to retard the B.O.D. of the starch.

An even more striking difference was shown in the B.O.D. values when 1 to 5 or 1 to 10 days series were run.

TABLE I.—B.O.D. Determinations of Sizings

Sizing	B.O.D. (p.p.m.)
CMC (7 varieties)	3.9 to 16
CMC ("warp size")	12 to 22
CMS (Carboxymethylated starch)	211
HPAN (an acrylnitrile)	5
HPAN + Globe corn starch (1:1)	375
VAMAD (a vinyl polymer)	168
SMAC (a styrene polymer)	42
Mixture containing starch M-1	660
Mixture containing starch M-2	295
Mixture containing starch M-3	200

TABLE II.—Values of k and L in the B.O.D. Formula for Various Sizings

Sizing	k	L
Corn starch solution	.26	981
Potato starch solution	.17	898
CMC ("warp size")	.03	495
CMC (relatively pure)	.01	278
CMS	.13	610

From these, the rate of first-stage B.O.D. activity (k) and the ultimate first-stage demand (L) were calculated. Some of these results are shown in Table II.

Several sets of trickling filters, both single-pass and recirculating, have been operated with settled domestic sewage alone, and with increasing increments of CMC warp size and potato starch. These experiments showed that, with 100 p.p.m. of CMC added, no additional 5-day B.O.D. load above that of the sewage was contributed either to the filters or by the effluents to the stream. With 250 p.p.m. of CMC there was a slight increase. With 100 p.p.m. of starch some increase was shown, and with 250 p.p.m., the increases both to the filter and to the stream were significant. With 500 p.p.m. of CMC, significant increases in the discharge to the stream were shown but these were one-half to two-thirds as great as those shown after the addition of 500 p.p.m. of starch.

Conclusions

It appears that, in many cases, the use of a substitute for some or all of the starch used in textile plants would give a sufficient reduction in B.O.D. load to justify its use. This is especially true in one-, two- or three-day B.O.D. values where early loads are particularly important. Additional careful studies of the use of starch substitutes by the textile industry are warranted in order to reduce the pollutional load upon streams and to reduce the cost of waste treatment.

TIPS AND QUIPS

Juvenile Education

Endeavoring to attack the problem of sewer stoppages due to miscellaneous items (toys, rags, silverware, sticks and stones) at is source, Robert J. Pallette, Superintendent of the El Cajon (Calif.) sewage treatment plant, has taken his crusade to the classroom. Through a series of talks to the public school students, Bob Pallette, has stressed the need for keeping these miscellaneous items out of the sewer. Emphasis is centered on the home and the sanitary facilities of kitchen and bathroom.

The classroom talks feature blackboard sketches of sinks, toilets, and bath tubs, showing how they are connected. A typical sewer system is traced from the trap to the treatment plant. The importance of keeping objects out of the sewer lines is emphasized. Problems which result from roots, sticks, sand and rocks are described.

In addition to the talk, each student receives a one-page mimeographed sheet carrying a foreword to the parents by the District Superintendent of Schools. Then follows a letter to the boys and girls by Superintendent Pallette. The letter is written for them and explains where they can help around the home in keeping miscellaneous items out of the waste lines.

Prior to the classroom education program it was necessary to clean rags, sticks, stones, small bottles and plastic toys from the bar screen at the treatment plant every 30 days. More frequent cleaning would have been preferred, except for the inaccessible location of the bar screen in a deep, closed inlet structure. After talking to the children it was 87 days before the bar screen had to be cleaned again.

In addition to the talks, visits are scheduled to the treatment plant. The total result is improved sewer maintenance and good publicity that helps the operating personnel at the end of the line.

First Prize

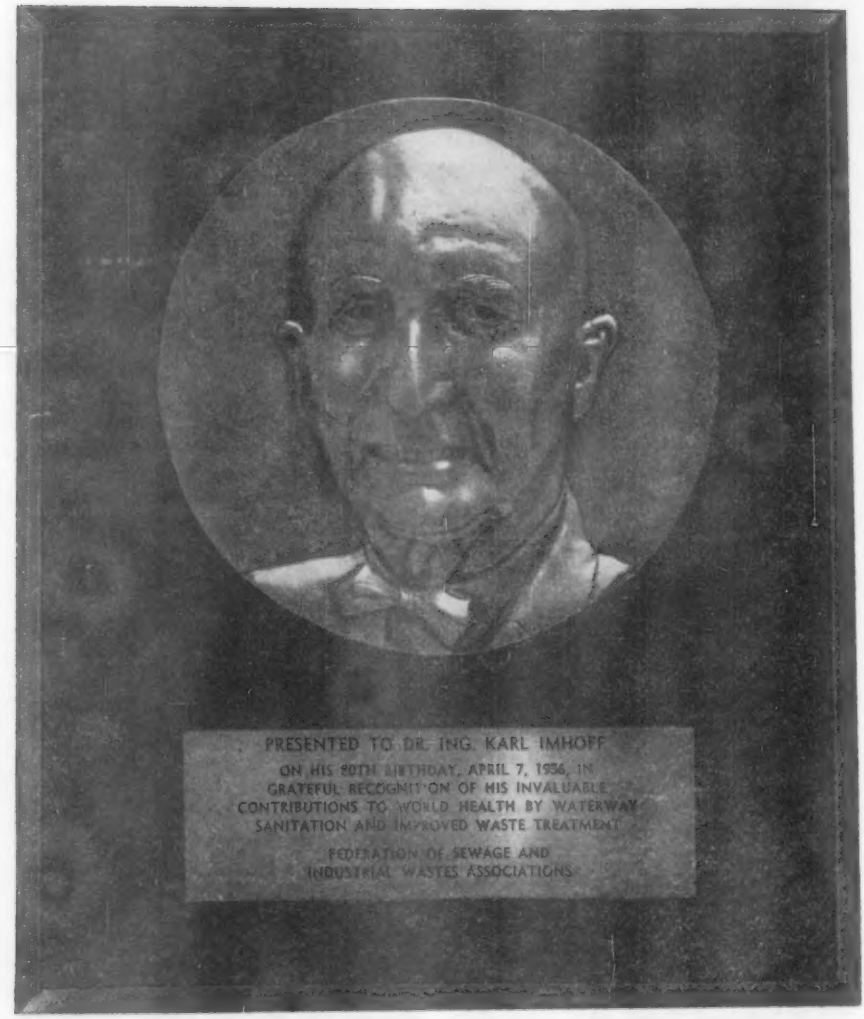
Last Christmas the Clarksville, Ind., sewage treatment plant won the $25 first prize in the commercial class of the Jaycee Christmas lighting contest. Superintendent Robert Riggle plans to use the prize money to start a decoration fund.

Motor Boating

Motor boating through the entrance gate to the Chehalis, Wash., sewage treatment plant was something new for Superintendent A. L. McGee. Abnormal rainfall resulted in the flooded condition of the Chehalis River and a 5-ft. rise or fall in river level in 24 hr. was not uncommon. Only the primary treatment units have been utilized during recent months and hydraulic overload has been 400 per cent. Fortunately the flooding has caused no operational damage to plant equipment, although it was deep enough to cause concern.

Centrifugal Sludge Pumping

In Europe it is considered fundamentally incorrect to pump sludge with a high speed centrifugal pump. The action of the pump tends to emulsify primary sludges and to break up the flocculation of secondary sludges, thus rendering their subsequent handling more difficult.


PRESENTED TO DR. ING. KARL IMHOFF
ON HIS 80TH BIRTHDAY, APRIL 7, 1956, IN
GRATEFUL RECOGNITION OF HIS INVALUABLE
CONTRIBUTIONS TO WORLD HEALTH BY WATERWAY
SANITATION AND IMPROVED WASTE TREATMENT
FEDERATION OF SEWAGE AND
INDUSTRIAL WASTES ASSOCIATIONS

Plaque presented to Karl Imhoff, Essen, Germany

Federation Affairs

KARL IMHOFF HONORED

Dr. Karl Imhoff, Consulting Engineer of Essen, Germany, is being honored by the Federation and other organizations on the occasion of his eightieth birthday, April 7, 1956.

By action of the Board of Control in October, 1955, the Federation Executive Committee was delegated to arrange recognition of this event so significant to the sanitary engineering world. The Committee decided on the presentation of a plaque as shown on the page opposite. The plaque has a facial likeness of Dr. Imhoff cast in bronze. The medallion is mounted on mahogany with a tablet inscribed: "Presented to Dr. Ing. KARL IMHOFF On his 80th Birthday, April 7, 1956, in grateful recognition of his invaluable contributions to world health by waterway sanitation and improved waste treatment. FEDERATION OF SEWAGE AND INDUSTRIAL WASTES ASSOCIATIONS."

The official observance of Dr. Imhoff's birthday is scheduled for April 9, 1956, in Bonn, Germany. Speakers will include two Bund Ministers and Dr. F. Schreier, President of the German Federation Member Association, Abwassertechnische Vereinigung. The Federation plaque is to be presented by Harold A. Thomas, Jr., Professor of Sanitary Engineering of Harvard University, who is touring Germany and other countries.

Dr. Imhoff's creative work in sanitary engineering is itself a monument to him. Many affiliated with the Federation are privileged to have personal acquaintance with him, and virtually all know his name and work in the field. All of us may take pride as participants in the presentation of this memento to him.

The career of the one being honored has always been completely devoted to improved sanitation through treatment of sewage and industrial wastes. His earliest training in German Institutes of Technology at Karlsruhe and Munchen gave him initial preparation for his technical life. In 1905, he received the degree of Doktor Ingenieur (Doctor of Engineering) from the Institute of Technology at Dresden. He was subsequently awarded honorary Dr. Ing. degrees by the Institutes of Technology at Karlsruhe (1930), Aachen (1949) and Stuttgart (1951). His engineering engagements included the position of Scientific Engineer for the Institute for Water Supply and Sewage Purification in Berlin and Engineer of the Emschergenossenschaft in Essen for 14 years. Partly concurrent with this assignment, he served as Engineer and Director of the Ruhrverband in Essen. In 1934 he resigned this post and has devoted his full time to consulting engineering since that date.

He is well known for his many writings and books. His *Taschenbuch Der Stadtentwässerung* appeared in 1956 in its 16th Edition. Other major works include *The Arithmetic of Sewage Treatment Works* (1929) and *Sewage Treatment* (1940), both coauthored with Dr. Gordon M. Fair of Harvard University.

The Federation showed its esteem for Dr. Imhoff in 1953 by conferring an Honorary Membership upon him. In addition, he has the distinction of being an Honorary Member of four of the five Federation Member Associations in Europe. They are Abwassentechnische Vereinigung (Germany), Verband Schweizerischer Abwasserfachleute (Switzerland), Institution of Public Health Engineers and Institute of Sewage Purification (England).

Dr. Imhoff's numerous friends throughout the Federation membership join in expressing appreciation for his technical contributions, as well as service to the Federation from its origin. This plaque, a small token of thanks, represents a deep feeling of gratitude for his helpfulness to the field through his leadership.

Reviews and Abstracts*

Chemical Treatment of Sewage. *Surveyor*, 114, 601 (June 5, 1955).

An abstract of a paper presented by T. Stones to the Institute of Sewage Purification. Two series of experiments are reported, one dealing with domestic sewage, and the other with "normal industrial sewage." Using alum alone, the domestic sewage required 150 p.p.m. and the industrial sewage 200 to 250 p.p.m. to show "any appreciable benefit." Addition of the theoretical quantity of lime improved the results obtained with domestic sewage when the alum dosage was 150 p.p.m. or less, and with industrial sewage up to alum dosages of 300 p.p.m. With higher alum dosages, the addition of lime was detrimental.

Addition of lime alone caused an initial drop in purification, followed by a sharp rise in both sewages tested. With 150 p.p.m. of alum, addition of increasing quantities of lime caused an initial rise in purification followed by a slight fall. With 300 p.p.m. of alum, the purification remained constant as lime was added up to pH 8 then decreased somewhat to a minimum at pH 9.5.

Sulfuric acid alone first decreased the degree of purification which then rose to a maximum at pH 3. When 150 or 300 p.p.m. of alum was added to either sewage the best purification was obtained when sulfuric acid was added to pH 5. Below pH 2.5 the results with alum plus acid were the same as with acid alone. M. C. RAND

Fungi in Domestic Sewage Treatment Plants. By JOSEPH C. BEEKER and CHARLES G. SHAW. *Applied Microbiology*, 3, 3, 173 (1955).

Two stage trickling filter sewage treatment plants in Moscow, Ida. and Pullman, Wash., were studied. Effluents from the different units were sampled and the fungi identified after growth on culture media. Direct microscopic observation of various slimes in effluents from the primary filter revealed no true fungus mycelium. When the filter had an abundant growth of fungi then microscopic examination of the filter effluent revealed the presence of fungi.

The quantity of any particular species of fungus was less on the later stages of treatment than in the earlier stages, indicating that fungal growth had not taken place in the sewage systems studied except for the growth of *Fusarium aquaedectuum* in the primary filter. The effluent from the primary filter did not show the presence of this organism indicating that the organism does not sporulate in this habitat. This might be true of other fungi which occur only in the vegetative stage and which do not break off and pass into the effluent.

Yeasts are eliminated from raw sewage as it passes through the sewage system. Samples taken from the digesters showed the presence of *Geotrechum candiduum*.

H. HEUKELEKIAN

Respiration Rate of Bacteria as a Function of Oxygen Concentration. By I. S. LONGMUIR. *Biochem. Jour.*, 57, 81 (1954).

The concentration of dissolved oxygen was measured continuously to 10^{-9} M. (.000032 p.p.m.) by a polarographic method employing a rotating gold electrode. This method was used to determine the respiration rate of bacteria as a function of oxygen concentration. The results obtained show that the respiration rate of bacteria is related to the oxygen concentration by the Michaelis-Menten equation for the affinity of an enzyme to its substrate. The constant for this equation, Km, can be taken to represent the concentration of oxygen at which bacteria respire at half their maximum rate. The Km values of various organisms were determined and were found to be related to the size of the organism. This relationship could be rep-

* Please send to Federation headquarters all periodicals, bulletins, special reports, etc., which might be suitable for abstracting in THIS JOURNAL. Publications of public health departments, stream pollution control agencies, research organizations, and educational institutions are particularly desired. Address such material: Federation of Sewage and Industrial Wastes Assns., 4435 Wisconsin Ave., N.W., Washington 16, D. C.

resented by an empirical formula; the larger organisms have a larger *Km* value. This relationship between *Km* value and size of organism is ascribed to diffusion. The *Km* values of intact cells and cell-free preparations of small organisms were approximately the same indicating that the *Km* of the small organism is not appreciably affected by diffusion. In the larger organisms *Km* values of the intact cells were higher than that of the cell-free preparations, indicating that diffusion is an important factor.

Even with the largest cells, the concentration of dissolved oxygen was low before becoming a limiting factor in the rate of respiration. Thus, with *B. megatherium*, the *Km* was 3.12×10^{-6} M. (0.1 p.p.m.). With small cells and enzyme preparations, *Km* values of the order of 10^{-8} M. (.0003 p.p.m.) were observed.

H. HEUKELEKIAN

Advances in Sewage Treatment in the Period from September 1, 1952 to October 1, 1954: Progress Report Committee on Sewerage and Sewage Treatment. *Proc. Amer. Soc. Civil Eng.*, **81**, Sep. No. 594 (Jan., 1954).

This report consists of 42 pages of reviews covering 270 articles on sewerage, industrial wastes, stream pollution, financing and garbage disposal. A bibliography is included.

Adequate use of headings and subheadings makes it possible to locate reviews according to the principle subject of each article. Most references are brief and give little more than the subject of the paper but many, especially those on all phases of sludge disposal include data and some mention of the findings or conclusions.

W. A. HASFURTHER

Respiration Studies on the Organic Nitrogen Preferences of Zooglea Ramigera. BY LINVIL G. RICH. *Applied Microbiology*, **3**, 1, 20 (1955).

Oxygen utilization rate of *Zooglea ramigera* in substrates containing various types of organic nitrogenous material was determined by measuring the dissolved oxygen change by the polarographic (dropping mercury electrode) method. The vessels in which the D.O. was determined were open to the atmosphere but not agitated. It was assumed that the diffusion of oxygen from the atmosphere would be negligible. Preliminary studies showed that the mercury had no effect on the respiration of the organism.

The oxygen utilization rate in various substrates was highest during the first 15 min. than subsequently up to 60 min. *Zooglea ramigera* exhibited a marked preference for proteoses and peptones over purified proteins and amino acids although the latter are utilized. Amino acids and proteins were utilized at about the same rate. Gelatin was utilized although it cannot be liquified by this organism. Glucose was utilized at a slow rate. Ammonium ions (25 p.p.m. or more) reduced the respiration rate of *Zooglea ramigera*.

H. HEUKELEKIAN

Biological Filtration of Sewage and Vacuum Filtration of Sludge. BY D. H. BARRACLOUGH. *Jour. Inst. of San. Eng.*, 54, Part 2, 124 (Apr., 1955).

This article describes experimental work at Reading (1949–1954), on a strong sewage containing considerable industrial wastes.

An activated sludge plant completed in 1925 is still in use but the effluent had become unsatisfactory, requiring extensions. Experiments were begun in 1948 on 13 biological filters, each 4-ft. 6-in. in diameter and 6-ft. deep, with various media, ranging from 1¼-in. to 4-in. size. High-rate filtration proved unsatisfactory and was abandoned in 1949.

Alternating double filtration and recirculation proved more practical, but the effluent only meets the requirements of the Thames Conservancy Board at a straight filtration rate of 50 gal. (Imp.) per cu. yd. per day. With alternating double filtration or recirculation, a rate of 100 gal. (Imp.) per cu. yd. per day proved practicable.

Tests were made on vacuum filtration of digested activated sludge (1953) on a filter with 10 sq. ft. area, using a fine nylon blanket and conditioning with various chemicals, such as chlorinated copperas, aluminum chloride and aluminum chlorohydrate. About 4 per cent aluminum chloride proved sufficient and 2.5 per cent aluminum cholohydrate with digested sludge gave an output of over 2 lb. per sq. ft. per hour and 80 per cent moisture content.

The results are tabulated and discussed by a number of speakers.

LANGDON PEARSE

A Note on the Enumeration of Sulfate Reducing Bacteria in Polluted Water and Their Inhibition by Chromate. By J. P. M. Drummond and J. R. Postgate. *Jour. of App. Bact.* (Brit.), 18, 2, 307 (July, 1955).

The addition of a reducing agent such as cysteine is essential for the enumeration of sulfate reducing bacteria by dilution or agar plate count methods if the results are to have any significance. Without cysteine the counts, even after a month of incubation, are only a fraction of the actual population. The method adopted was primary enrichment of sulfate reducers in medium containing cysteine. All tubes that showed blackening due to cysteine decomposing and sulfate reducing bacteria were subcultured in cysteine-free medium. The blackening of the latter tubes could only be due to sulfate reducing bacteria.

A clay pit one-half filled with domestic refuse, became waterlogged and produced hydrogen sulfide odors. Upon filling the shallow areas with some earth, the nuisance ceased. Examination showed 400 p.p.m. CrO_3 which was probably derived from the earth. When refuse dumping was resumed the odors did not become offensive again until the chromate concentration was almost zero. Additional chormate was added and the odor was controlled again.

H. Heukelekian

Bio-Oxidation of Pulp Mill Wastes. *Chem. Eng.* (Aug., 1955).

An activated sludge treatment plant for processing wastes from the pulp and paper mill of the West Virginia Pulp and Paper Co., Covington, Va., has a rated capacity of 16 m.g.d. with a maximum of 24 m.g.d. Its purpose is to reduce the B.O.D. of the pulp mill wastes from 140 p.p.m. to 15 p.p.m. The effluent is discharged into the Jackson River, which has a flood flow of 10,000 m.g.d., but a summer flow of about 40 m.g.d. The mill uses about 30 m.g.d.

A five-step process consists of primary settling (2-hr. detention); addition of 75 per cent phosphoric acid to give 2 p.p.m. of phosphorus and 35 per cent aqua ammonia to give 4 p.p.m. of nitrogen to the primary effluent; aeration of a mixture of waste liquor and activated sludge; final sedimentation and return of the sludge to the incoming raw wastes.

The mill wastes are collected in a settler control which feeds the primary settling tank. Sediment mixed with excess activated sludge is pumped to a fly-ash lagoon, and discharged to the river during flood stage.

Final clarifiers have sludge collecting mechanisms to withdraw controlled quantities of excess activated sludge for storage (24-hr. period) for recovery and reuse.

In starting the plant, sludge was trucked in from a municipal plant at Roanoke, Va.

Langdon Pearse

The Bacterial Dissimilation of Naphthalene. By J. F. Murphy and R. W. Stone. *Canadian Jour. of Microbiology*, 1, 7, 579 (Aug., 1955).

Data are presented indicating the major pathway for the oxidation of naphthalene by a strain of Pseudomonas occurs via salicylic acid, which is further oxidized through catechol to B-ketoadipic acid. Evidence was found that a second pathway of naphthalene oxidation produces 1,2-naphthoquinone. 1,2-dihydroxynaphthalene was found to be non-enzymatically converted to 1,2-naphthoquinone. The 1,2-naphthoquinone was not further metabolized and was found to be responsible for the characteristic brown to reddish orange color of the culture medium. Omission of $FeCl_2$ and $MgSO_4$ from the basal medium prevented the formation of salicylic acid but did not interfere with the production of 1,2-naphthoquinone. H. Heukelekian

Inland Waterways—Pollution and Ancillary Matters. By C. Loifthouse. *Jour., The Royal San. Inst.*, 75, 5, 320 (May, 1955).

Comments are presented on the condition of navigable rivers which need further attention to remove pollution, particularly the River Thames below London; also the effect of power stations, where water is used for cooling purposes. A study is given on the effect of augmenting the river flow with sewage effluent, and the standards developed (B.O.D. not to exceed 25 p.p.m., suspended solids not to exceed 50 p.p.m.). The maximum permissible temperature of water discharged ranges from 65° F. in the winter to 85° F. in the summer. In another case the power station agreed not to heat the river above 90° F., or not more than 20° F. above the stream supplying the station. Langdon Pearse

Pollution of the Sea by Sewage. *Jour., The Inst. of San. Eng.*, 54, Part 2, 122 (Apr., 1955).

This is a brief reprint of an article in the *British Med. Jour.*, Nov. 20, 1954, which discusses pollution of bathing beaches in Great Britain, and an outbreak in paratyphoid fever, traceable to a carrier engaged in the sale of ice cream. *Salm-paratyphi B.* was isolated in the beach pollution near the sewer outfall. LANGDON PEARSE

Use of Towns' Refuse in Agriculture. A Study by the Natural Resources (Technical) Committee. Her Majesty's Stat. Off., London, Eng. (1954). 25 pp.

The total annual quantity of dry solids in the domestic and industrial sewage in England and Wales is about one million tons. About 100,000 tons from coastal areas is discharged directly to the sea and a similar quantity from dwellings not served by public sewers is disposed on the land. The dry solids recovered at sewage disposal works is about 800,000 tons, of which 350,000 tons are already applied to the land. About 5 per cent is unsuitable for agricultural use because of toxic constituents and the remaining 400,000 tons contain 10,000 tons of nitrogen, 5,000 tons P_2O_5 and 1,200 tons K_2O.

About 10.5 million tons of household refuse is collected, containing 4 million tons of fine dust and 1.3 million tons of putrescible organic matter. The dust contains 20,000 tons each of nitrogen, phosphoric acid and potash and the organic matter contains 4,000 tons of nitrogen.

Over a period of a year, the wastes from towns contain one-half as much nitrogen as is annually applied to land as nitrogenous fertilizer. Unused sewage sludge is the only waste immediately available for use in agriculture. Its nitrogen content is equivalent to about 5 per cent of the United Kingdom nitrogenous fertilizer consumption. Composting is only a partial solution of the sludge disposal program.

On a fresh weight basis, there is little difference between town wastes compost and farmyard manure in content of nitrogen and phosphorus, but compost contains much less potash. Sewage sludge has a lower fertilizing value than farmyard manure. Fine refuse dust and composts made from household refuse have little economic value.

The organic matter in unused towns wastes amounts to ¾ million tons per year. In contrast, the organic matter added to the soil in normal farming is some 17.5 million tons.

The report concludes that composts of sewage sludge and garbage on a minor scale may be justified where conditions are favorable. In general, it appears uneconomical. Three-quarters of the nitrogen in sewage, about 60,000 tons, is lost in the effluent. The committee suggests that methods should be studied for the recovery of at least a part of this nitrogen.

LANGDON PEARSE

BOOKS, REPORTS, PAMPHLETS

Ten Year Report, 1945–1954. National Sanitation Foundation, Ann Arbor, Mich. (1955).

Water Management in Florida. *Bull. of Florida Eng. and Exper. Sta.*, Univ. of Florida, Gainesville, Fla., 9, 5 (Bull. Series No. 72). 96 pp. Price, $1.00 (1955).

Proceedings of the 8th Municipal and Public Health Engineering Conference, held March 15–16, 1955.

Profits from Pollution Control. Information Series No. 7, Washington Pollution Control Comm., Olympia, Wash. (1955).

Pulp and Paper Mill Pollution Problems. Information Series No. 8, Washington Pollution Control Comm., Olympia, Wash. (1955).

A Glossary of Sanitary-Engineering Terms. By PETER C. G. ISAAC. Dept. of Civil Eng., Bull. No. 4, Univ. of Durham, King's College, Newcastle upon Tyne, England. 72 pp. Price 5/– (1955).

Municipal Water Facilities Communities of 25,000 Population and Over. USPHS, Washington, D. C. 153 pp. (1955).

A cooperative State-Federal Report as of Dec. 31, 1954 for the United States.

Book Reviews

Taschenbuch Der Stadtentwässerung. (Handbook of Municipal Drainage) By Karl Imhoff. 16th Edition. R. Oldenbourg Verlag, Munich, Germany, 338 pp. (1956).

This German book was originally published 50 years ago primarily as a guide for the younger engineers of the Emschergenossenschaft. Its purpose was to give these engineers the fundamentals of the subject in a concise form and in the simplest language possible.

This 16th Edition has retained these basic principles by avoiding difficult formulas and calculations. Instead, practical experiences have been cited to indicate current usage. There are numerous illustrations and references to the technical literature of Germany, Britain and the United States.

Principal changes in this edition from the Fifteenth Edition (1954) include data on increased treatment rates of sewage treatment processes, additional examples, detailed information on process efficiencies, costs of construction and operation, and improvements of sewage treatment processes, individually and collectively.

It is fitting to observe that this book has contributed notably to the knowledge in the waste treatment field for 50 years. In 1929 the Taschenbuch was translated into English under the title "The Arithmetic of Sewage Treatment Works" by Dr. Gordon M. Fair. In 1933 it was translated into Polish, in 1934 Italian, in 1935 French and Spanish, and in 1950 Yugoslavian. In 1940 the book was published in the United States under the title "Sewage Treatment" by Imhoff and Fair.

While the volume is a valuable technical reference, it will provide many non-German users an opportunity to maintain and advance their German language knowledge.

R. E. Fuhrman

Principles of Sewage Treatment. By Willem Rudolfs. Fourth Edition. National Lime Assn., Washington, D. C. 130 pp. Price, $1.37 Postpaid (1955).

This completely revised edition of a popular elementary reference manual reflects the advances made in the sewage treatment field since publication of the first edition in 1941. The manual, now available in cloth binding, has long been a favorite introductory work for sewage treatment personnel and as a supplementary text in sanitary engineering courses.

The new edition contains a number of revisions in the text, including new illustrations of sewage treatment equipment. No attempt has been made to cover in detail all of the various modifications of standard treatment processes. Written in simple, straightforward manner, the text covers the basic principles of sewage treatment. Chapter coverage includes sources and composition of sewage, stabilization, treatment methods, sludge processing and chlorination. The section on sewage treatment plant operation includes common operating problems. A chapter on methods of sewage analysis and the microbiology of sewage treatment will introduce the reader to subjects worthy of additional study.

D. P. Schiesswohl

Federation of Sewage and Industrial Wastes Associations

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1956

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HONORS AND AWARDS

Honorary Members

The qualifications for Honorary membership in the Federation are set forth in Article II, Section 4 of the By-laws. Honorary Members are elected upon recommendation by a committee comprising the President and four latest Past Presidents, the senior Past President as chairman, in accordance with a policy adopted by the Board of Control on October 23, 1943. Honorary Members elected to date are as follows:

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Gordon Maskew Fair	1955

The Harrison Prescott Eddy Medal

The Harrison Prescott Eddy Medal is awarded annually to a member of any Member Association of the Federation for outstanding research contributing in important degree to the existing knowledge of the fundamental principles or processes of sewage treatment, as comprehensively described and published during any stated year in SEWAGE AND INDUSTRIAL WASTES. The award commemorates Harrison Prescott Eddy, a famous engineer and a pioneer in the art of sewage treatment.

Past recipients of the award are:

Harry Willard Gehm	1943
John Raymond Snell	1944
Lloyd R. Setter	1945
H. Heukelekian	1946
Richard Pomeroy and Fred D. Bowlus	1947
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Donald M. Pierce	1953
William J. Oswald, Harold B. Gotaas, Harvey F. Ludwig, and Victoria Lynch	1954
William J. Katz, William L. Lea, Gerard A. Rohlich	1955

*Deceased

The George Bradley Gascoigne Medal

The George Bradley Gascoigne Medal is awarded annually to a member of any Member Association of the Federation for outstanding contribution to the art of sewage treatment works operation through the successful solution of important and complicated operational problems, as comprehensively described and published during any stated year in SEWAGE AND INDUSTRIAL WASTES. This award is a memory of George Bradley Gascoigne, a prominent consultant from 1922 to 1940, who demonstrated an unusual interest in matters of sewage works operation.

Past recipients of this award are:

Kerwin L. Mick.....1943
James T. Lynch and Uhl T. Mann....1944
John D. McDonald.....1945
LeRoy Winfield Van Kleeck.....1946
Leon S. Kraus.....1947
David P. Backmeyer.....1948
Wilbur N. Torpey.....1949
Clarence E. Keefer.....1950
Leonard S. Hillis.....1951
Walter Asa Sperry.....1952
W. N. Wells and Clarence H. Sherer..1953
Robert Ditmar Bargman.....1954
Abraham H. Chasick.....1955

The Charles Alvin Emerson Medal

The Charles Alvin Emerson Medal is awarded annually to a member of any Member Association of the Federation "for outstanding service in the sewerage and sewage treatment works field, as related particularly to the problems and activities of the Federation of Sewage and Industrial Wastes Associations in such terms as the stimulation of membership, improving standards of operational accomplishments, fostering fundamental research, etc." This award honors Charles Alvin Emerson, who served as President of the Federation from 1928 to 1941 and holds the distinction of being its first Honorary Member.

Past recipients are:

Floyd William Mohlman.....1943
Willem Rudolfs.....1944
Harold Warner Streeter.....1945
F. Wellington Gilcreas.....1946
Langdon Pearse.....1947
LeRoy Winfield Van Kleeck.....1948
William J. Orchard.....1949
Morris M. Cohn.....1950
Howard Eugene Moses.....1951
*Frank Woodbury Jones 1952
William D. Hatfield.....1953
*Charles C. Ruchhoft.....1954
Merle Starr Nichols.....1955

The Industrial Wastes Medal

The Industrial Wastes Medal was established in 1949 to be awarded annually in the form of a plaque for the most outstanding contribution by an industrial employee on any aspect of industrial wastes control, as published in SEWAGE AND INDUSTRIAL WASTES during the year preceding the award.

Past recipients are:

Roy F. Weston, Robert G. Merman and Joseph G. DeMann.....1950
Bruce W. Dickerson.....1951
Robert J. Austin, Roy N. Giles, C. T. Nicholson, and F. W. Sciene-man 1952
Richard H. Coe.....1953
*N. H. Sanborn.....1954
Kenneth S. Watson.....1955

The Kenneth Allen Award

From 1943 through 1948, meritorious personal service to the Member Associations of the Federation was recognized by the Kenneth Allen Award. The award was retired in 1948.

* Deceased.

Recipients of this award have been:

1943

Harry Thornton Calvert (ISP)
Edward F. Eldridge (Mich.)
John Kurtz Hoskins (Fed.)
Fred Merryfield (Pac. N.W.)
Edward P. Molitor (N.J.)
Robert S. Phillips (N.C.)
Alfred Henry Weiters (Iowa)
William Homer Wisely (Cen. St.)

1944

Albert Edward Berry (Can.)
Van Porter Enloe (Ga.)
Albert Legrand Genter (Md.-Del.)
F. Wellington Gilcreas (New Eng.)
Charles A. Holmquist (N.Y.)
Dana Ewart Kepner (Rocky Mtn.)
Leon Benedict Reynolds (Calif.)
Wilson Waldo Towne (Dak.)

1945

Howard Eugene Moses (Pa.)
George S. Russell (Mo.)
Dario Travaini (Ariz.)
Frederick Holman Waring (Ohio)
Joe Williamson, Jr. (Fla.)
Murray Alderson Wilson (Kans.)

1946

E. J. M. Berg (Texas)
Frank E. DeMartini (Fed.)
John R. Downes (N.J.)
Thomas J. Doyle (Mich.)
John Henry Garner (ISP)
Harold Benedict Gotaas (N.C.)
William P. Hughes (Pac. N.W.)
Theodore R. Lovell (Iowa)
George W. Martin (Cen. St.)

1947

William T. Knowlton (Calif.)
Floyd W. Pinney (Dak.)
Gilbert R. Frith (Ga.)
Clarence E. Keefer (Md.-Del.)
Stuart E. Coburn (New Eng.)
Wellington Donaldson (N.Y.)
Henry J. Darcey (Okla.)
Carroll H. Coberly (Rocky Mtn.)
William Storrie (Can.)
William Merriman Cobleigh (Mont.)

1948

George W. Marx (Ariz.)
David Bryon Lee (Fla.)
William Q. Kehr (Mo.)
F. Dean Stewart (Ohio)
Francis deSales Friel (Pa.)

The Arthur Sidney Bedell Award

Established in 1948, the Arthur Sidney Bedell Award acknowledges extraordinary personal service to the Member Associations of the Federation. Each Member Association is privileged to name one of its members to receive the award, which may be earned by organizational leadership, administrative service, membership activity, stimulation of technical functions, or similar participation. The frequency of nomination varies from annually to one in three years, depending on membership. The award is named for the second President of the Federation, who exemplified its purpose by his long devotion and contribution to the affairs of the New York State Sewage Works Association (now the New York Sewage and Industrial Wastes Association).

Past recipients follow:

1949

Harry P. Croft (N.J.)
Victor Marcus Ehlers (Texas)
R. Paul Farrell (Ky.-Tenn.)
Carl Edwin Green (Pac. N.W.)
Frederick Leon McDonald (Ark.)
William Thomas Lockett (ISP)
William McKinney Piatt (N.C.)
Walter Asa Sperry (Cen. St.)
Harold Warner Streeter (Fed.)
John L. Strelow (Iowa)

1950

Leland Bradney (Dak.)
John Chester Brigham (N.Y.)
Herbert B. Foote (Mont.)
L. L. Hedgepeth (Va.)
Theodore J. Lafreniere (Can.)
Robert G. McCall (W. Va.)
Edward Alexander Reinke (Calif.)
Frank S. Taylor (Okla.)
LeRoy Winfield Van Kleeck (New Eng.)
William Hugh Weir (Ga.)
Leonard Oliver Williams, Jr. (Rocky Mtn.)
Abel Wolman (Md.-Del.)

1951

Roy Binder (Kans.)
John Clinton Clark (Ala.)
John Raymund Hoffert (Pa.)
John Robertson Hoy (Fla.)
Arthur H. Niles (Ohio)
Charles Henry Trusler (ISE)
Harold W. Yost (Ariz.)
Francis M. Veatch (Mo.)

1952

Don E. Bloodgood (Cen. St.)
Herman Glenn Baity (N.C.)
Paul Bolton (Iowa)
P. N. Daniels (N.J.)
Francis W. Kittrell (Ky.-Tenn.)
Ray E. Koon (Pac. N.W.)
Winfred S. Mahlie (Texas)
Clarence Theodore Mudgett (Mich.)
Walter F. Freeborn (ISP)
Harrison Hale (Ark.)
George Ashby Rhame (S.C.)

1953

Robert James Auld (P. Rico)
Charles G. Caldwell (Rocky Mtn.)
Nathan M. deJarnette (Ga.)
Anthony J. Fischer (N.Y.)
Ralph E. Fuhrman (Md.-Del.)
Quintin B. Graves (Okla.)
John B. Kleven (Dak.)
Douglas L. McLean (Can.)
Walter E. Merrill (N.Eng.)
Fred F. Palmer (Mont.)
Eugene C. Meredith (Va.)
Henry W. Speiden (W.Va.)
Arthur T. Wintersgill (Calif.)

1954

Arthur N. Beck (Ala.)
Merle V. Ellis (Ariz.)
John W. Wakefield (Fla.)
Max Prüss (German)
Gilbert T. Cotterell (ISE)
Leland A. Talbot (Kan.)
Charles A. Haskins (Mo.)
Theodore C. Schaetzle (Ohio)
Bernard S. Bush (Pa.)
Arnold Hoerler (Swiss)

1955

C. H. French (Ark.)
Frederick G. Nelson (Calif.)
George J. Schroepfer (Cen.St.)
Carl E. Schwob (Fed.)
Leo Holtkamp (Iowa)
F. T. Hambleton (ISP)
Herman D. Regan (Ky-Tenn.)
James L. Love (La.)
Thomas J. Powers (Mich.)
William F. Rapp (Neb.)
Henry Van Der Vliet (N.J.)
R. C. Sweeney (N.Y.)
P. D. Davis (N.C.)
Emil C. Jensen (Pac.N.W.)
T. R. Haseltine (Pa.)
W. T. Linton (S.C.)
Nils Westberg (Sweden)
J. H. Sorrels (Tex.)

The William D. Hatfield Award

The William D. Hatfield Award recognizes outstanding annual sewage works operation reports. Following the 1946 award, the Board of Control authorized identical awards for outstanding annual reports prepared (I) for plants serving less than 10,000

population, (II) for plants serving populations of 10,000 to 100,000, and (III) for plants serving populations of more than 100,000 persons.

Recipients of this award have been:

1946

Walter M. Kunsch

1947

F. E. Peterson (I)
John R. Szymanski (II)
Warren H. Sleeger and George J. Schroepfer (III)

1948

F. E. Peterson (I) *
Thomas T. Hay (II)
Kerwin L. Mick (III)

1949

Russell D. Craun (I)
George W. Martin (II)
Thomas T. Hay (II) *

1950

William L. Edwards (I)
Walter A. Sperry (II)
John R. Szymanski (II) *
John W. Johnson (III)

1951

William L. Edwards (I) *
J. E. Meers (II)
John R. Szymanski (II) *
George H. Craemer (III)
Kerwin L. Mick (III) *

1952–3

No awards.

1954

Uhl T. Mann (II)
J. E. Meers (II) *
C. W. Christenson (Indus.)

1955

No awards.

* Previous winner.

Membership Prizes

Prizes for membership activity in its various Member Associations have been awarded by the Federation since 1943. The numerical prize is given to the Member Association having the greatest numerical increase in membership during the year ending September 30 of the award year. The percentage prize is given for the greatest percentage increase in membership during the same period. The following Member Associations have received these prizes:

	Association			*Association*	
Year	*Num.*	*%*	*Year*	*Num.*	*%*
1943	Cen. St.	Fed.	1949	Ohio	Ala.
1944	Cen. St.	Mo.	1950	Iowa	La.
1945	Can.	Ariz.	1951	Mich.	ISE
1946	Can.	Okla.	1952	Cen. St.	Fla.
1947	ISP	Ark.	1953	Calif.	P. Rico
1948	Pa.	W. Va.	1954	Pa.	P. Rico
			1955	Mich.	Ga.

The Quarter Century Operators' Club

The Quarter Century Operators' Club is an informal group comprising Active or Corporate Members of any Member Association who had been engaged in sewage treatment works operation, on a full-time resident basis, twenty-five years prior to the date of their admission into the Club. The Club was created in 1941 under the sponsorship

of Frank Woodbury Jones, who served as its first registrar. The present registrar is Henry Van Der Vliet.

Harry M. Beaumont
Don E. Bloodgood
Floyd G. Browne
*Julius W. Bugbee
Raymond G. Case
E. Sherman Chase
Morris M. Cohn
Rodney E. Cook
P. N. Daniels
Nicholas DeHaas, Sr.
Earl Devendorf
George E. Flower
Harry M. Freeburn
E. D. Fry
G. L. Fugate
Arnold H. Goodman
William P. Gyatt
T. K. Haseltine
Wm. C. Hamm
George I. Hanson
William D. Hatfield
*Frank W. Jones
Harry J. Krum
Roy S. Lanphear
Carl C. Larson
John V. Lewis
George S. Long
Winfield S. Mahlie
C. D. McGuire
Edwin C. McKeeman
C. T. Mudgett
E. L. Nance
I. H. Nevitt
Arthur H. Niles
Andrew Palmer
John R. Palmer
Wm. M. Piatt
Wm. A. Ryan
Theodore C. Schaetzle
Glenn Searls
Russell S. Smith
Willard R. Smith
H. W. Streeter
John Struss
Myron W. Tatlock
S. L. Tolman
Henry Van Der Vliet
Edwin B. Wagner
Charles E. Wheeler, Jr.

* Deceased.

ANNUAL MEETINGS AND CONVENTIONS

No.	*Location*	*Date*
1	Chicago, Ill.†	Oct. 16, 1928
2	New York, N. Y.†	Jan. 18, 1929
3	New York, N. Y.†	Jan. 14, 1930
4	New York, N. Y.†	Jan. 22, 1931
5	New York, N. Y.†	Jan. 22, 1932
6	New York, N. Y.†	Jan. 19, 1933
7	New York, N. Y.†	Jan. 18, 1934
8	New York, N. Y.†	Jan. 18, 1935
9	New York, N. Y.†	Jan. 16, 1936
10	New York, N. Y.†	Jan. 22, 1937
11	New York, N. Y.†	Jan. 21, 1938
12	New York, N. Y.†	Jan. 20, 1939
13	New York, N. Y.†	Jan. 18, 1940
	Chicago, Ill.‡	Oct. 3–5, 1940
14	New York, N. Y.†	Jan. 15, 1941
	New York, N. Y.‡	Oct. 9–11, 1941
15	Cleveland, Ohio§	Oct. 22–24, 1942
16	Chicago, Ill.§	Oct. 21–23, 1943
17	Pittsburgh, Pa.§	Oct. 12–14, 1944
18	Chicago, Ill.†	Oct. 17–18, 1945
19	Toronto, Ont., Can.§	Oct. 7–9, 1946
20	Philadelphia, Pa.†	Oct. 10, 1947
	San Francisco, Calif.‡	Jul. 21–24, 1947
21	Detroit, Mich.§	Oct. 18–21, 1948
22	Boston, Mass.§	Oct. 17–20, 1949
23	Washington, D. C.§	Oct. 9–12, 1950
24	St. Paul, Minn.§	Oct. 8–11, 1951
25	New York, N. Y.§	Oct. 6–9, 1952
26	Miami, Fla.§	Oct. 13–16, 1953
27	Cincinnati, Ohio§	Oct. 11–14, 1954
28	Atlantic City, N. J.§	Oct. 10–13, 1955

† Annual business meeting of Board of Control.
‡ Convention of membership-at-large.
§ Annual business meeting of Board of Control and convention of membership-at-large.

DIRECTORY OF COMMITTEES

1955–56

Constitutional Committees

(*See Article VI of Bylaws*)

EXECUTIVE COMMITTEE OF THE BOARD OF CONTROL

G. W. Martin, *Chairman*

D. B. Lee
J. W. Cunningham
W. S. Wise
F. G. Nelson
E. C. Jensen
W. A. Hardenbergh

Publications Committee

The Publications Committee arranges the technical programs for the annual conventions of the Federation and has general supervision of all publications of the Federation.

Rolf Eliassen, *Chairman*

G. E. Symons, *Vice-Chairman*

A. J. Fischer
F. W. Gilcreas
L. L. Hedgepeth
R. W. Hess
W. Garber
L. S. Kraus
F. W. Mohlman
V. Bacon
D. B. Smith
R. E. Fuhrman

Organization Committee

The Organization Committee examines and reports to the Board on applications for membership in the Federation and endeavors to encourage the formation of new regional associations or conferences eligible for membership.

Seth G. Hess, *Chairman*

J. W. Wakefield
R. H. Hess

Sewage and Industrial Wastes Practice Committee

The Sewage and Industrial Wastes Practice Committee reviews and directs for publication any resolution, report, or publication which establishes professional or technical standards in the name of the Federation. The following Manuals of Practice have been published under the direction of the committee:

No. 1—Occupational Hazards in Sewage Works (1944)
No. 2—Utilization of Sewage Sludge as Fertilizer (1946)
No. 3—Municipal Sewer Ordinances (1949)
No. 4—Chlorination of Sewage and Industrial Wastes (1951)
No. 5—Air Diffusion in Sewage Works (1952)

Morris M. Cohn, *Chairman*

D. E. Bloodgood, *Vice-Chairman*

T. W. Clapham
E. B. Cobb
C. E. Keefer
Kerwin L. Mick
F. W. Mohlman
H. E. Orford
Langdon Pearse
D. M. Pierce
L. W. Van Kleeck
F. M. Veatch
R. E. Fuhrman

Subcommittee on Sewer Maintenance

This subcommittee of the Sewage and Industrial Wastes Practice Committee has been directed to develop a Manual of Practice on "Maintenance of Sewers and Appurtenant Structures." The first draft of the manual is in preparation.

T. W. Clapham, *Chairman*

A. A. Appel, *Vice-Chairman*

N. S. Bubbis
H. J. Graeser
J. L. Klamm
M. B. Nixon
G. M. Olewiler
Sydney Preen
C. S. Seabrook
L. E. West

Subcommittee on Standardization of Units

This subcommittee of the Sewage and Industrial Wastes Practice Committee has been assigned to develop an approved schedule of units to be used in the reporting of

plant operation and laboratory data. A committee of about forty members is engaged in revising a preliminary draft.

H. E. Orford, *Chairman*

Subcommittee on Trickling Filters

This subcommittee of the Sewage and Industrial Wastes Practice Committee is engaged in the development of a Manual of Practice to be entitled "Trickling Filters—Their Characteristics and Loadings."

W. S. Mahlie, *Chairman*

B. F. Hatch Kenneth V. Hill

Wm. E. Stanley

Subcommittee on Sewage Works Accounting

This subcommittee was created in 1946 for the purpose of developing a Manual of Practice on accounting procedures for municipal sewage works functions. Mimeographed copies of the manual in tentative form were made available for purchase in April, 1949.

F. M. Veatch, *Chairman*

G. J. Beiswanger E. A. Farmer K. K. Wallace
Alfred A. Estrada S. I. Zack

Subcommittee on Paints and Protective Coatings

This subcommittee has the function of assembling experience and data on paints and protective coatings used in sewage works, to be presented with recommendations in the form of a manual. The subcommittee was created in 1946 and the first draft of the manual is now being prepared for critical review.

Kerwin L. Mick, *Chairman*

Virgil Anderson W. T. McClenahan F. W. Pinney
J. W. Johnson M. L. Robins
L. S. Kraus Walter A. Sperry

Subcommittee on Vacuum Filtration of Sludge

This subcommittee was created in 1951 for the purpose of developing a Manual of Practice on vacuum filtration of sewage sludge.

E. B. Cobb, *Chairman*

J. D. McDonald W.E. Stanley L. W. Van Kleeck

Subcommittee on Operation of Sewage Plants

This subcommittee was created in 1953 for the purpose of developing a Manual of Practice on sewage plant operation.

D. M. Pierce, *Chairman*

A. P. Troemper, *Vice-Chairman*

Ben Benas F. E. Eldridge A. H. Niles
W. M. Bingley G. E. Griffin H. G. Rogers
D. E. Bloodgood L. S. Kraus C. I. Sterling, Jr.
P. N. Daniels W. S. Mahlie G. E. Symons
R. E. Fuhrman L. W. Van Kleeck

Subcommittee on Sewage Treatment Plant Design

The following Federation representatives were appointed in 1955 to serve jointly with representatives of the American Society of Civil Engineers in the production of a manual of practice.

T. R. Haseltine — M. H. Klegerman — G. W. Martin
G. E. Hubbell — F. D. Wraight

Subcommittee on Storm and Sanitary Sewer Design

The following Federation representatives were appointed in 1955 to serve jointly with representatives of the American Society of Civil Engineers in the production of a manual of practice.

C. G. Gaither — L. L. Sphar — C. R. Velzy
H. S. Smith — S. I. Zack

Research Committee

The Research Committee has the function of stimulating research work among the various Member Associations, and of cooperating with other organizations in the promotion of research.

H. Heukelekian, *Chairman*

H. E. Orford, *Vice-Chairman*

H. Amberg
G. Berger
D. E. Bloodgood
N. S. Chamberlin
W. E. Dobbins
G. P. Edwards
M. B. Ettinger
T. deS. Furman
A. E. Griffin
I. Gellman
C. Henderson
A. Hirsch
R. D. Hoak
R. S. Ingols
P. W. Kabler
Max Katz
R. P. Logan
R. M. Manganelli
P. H. McGauhey
W. Allen Moore
G. Paine
C. M. Palmer
G. A. Rohlich
L. R. Setter
C. M. Tarzwell
W. W. Towne
H. A. Trebler

Subcommittee on Toxicity of Industrial Wastes

This subcommittee of the Research Committee is functioning in three sections:

Section I. Critical review of literature; P. Doudoroff, *Chairman*, C. E. Barnes, H. Heukelekian, G. P. Edwards, F. W. Kittrell, M. Katz, C. E. Renn and R. F. Weston.

Section II. Development of methods for toxicity determinations on wastes; R. S. Ingols, *Chairman*, D. E. Bloodgood, M. L. Granstrom, T. Jaffee, N. L. Nemerow, M. L. Robins, W. W. Sanderson, C. N. Sawyer and J. H. Sorrels.

Section III. Development and standardization of bio-assay methods; P. Doudoroff, *Chairman*, B. G. Anderson, G. E. Burdick, P. S. Galtsoff, W. B. Hart, R. Patrick, E. R. Strong, E. W. Surber and W. M. Van Horn.

Finance Committee

The Finance Committee develops the annual operating budget of the Federation and affords guidance to the Board of Control in financial affairs.

W. J. Orchard, *Chairman*

G. W. Martin — D. B. Lee

Committee on Standard Methods of Sewage and Industrial Wastes Analysis

Created by the Board of Control on January 22, 1931, the Committee on Standard Methods of analysis was given constitutional status in October, 1953. The committee develops, perfects and modifies standard methods for the analysis of sewage and industrial wastes and of sludges or by-products therefrom. It also functions with similar committees of the American Water Works Association and American Public Health Association in the production of the laboratory manual *Standard Methods for the Examination of Water and Sewage*, the tenth edition of which was published early in 1955.

G. P. Edwards, *Chairman*

R. S. Ingols, *Vice-Chairman*

Ovid Baker
D. E. Bloodgood
A. M. Buswell
C. J. Carney
N. S. Chamberlin
R. V. Day
P. De Falco, Jr.
W. E. Dobbins
J. D. Fairing
K. Frashina
M. Ginn
C. F. Gurnham
W. D. Hatfield
L. L. Hedgepeth
W. L. Henderson
H. Heukelekian
R. D. Hoak
E. F. Hurwitz
J. E. Kinney
R. R. Kountz
J. B. Lackey
G. W. Lawton
K. M. Mackenthun
H. C. Marks
W. Maske
R. G. McCall
J. A. McCarthy
M. G. Mellon
W. A. Moore
J. C. Morris
N. L. Nemerow
M. S. Nichols
F. E. Nussberger
R. Pomeroy
M. L. Robins
G. A. Rohlich
W. W. Sanderson
C. N. Sawyer
L. R. Setter
C. M. Tarzwell
R. F. Weston

Special Committees

Committee on Awards

The Committee on Awards was created by the Board of Control on October 11, 1941. Functions of the committee are to advise the Board on matters of award procedures and to make recommendations as to the annual winners of the Eddy, Gascoigne, Emerson, and Industrial Wastes medals.

R. D. Bargman, *Chairman*

J. C. Dietz
R. E. Stiemke

Honorary Membership Committee

Authorized by the Board of Control on October 24, 1942, this committee is comprised of the President and four latest, living Past Presidents with the senior Past President as chairman. The committee reviews nominations for election to the grade of Honorary Member and makes recommendations to the Board on such nominations.

Earnest Boyce, *Chairman*

E. Sherman Chase
D. B. Lee
L. J. Fontenelli
G. W. Martin

Plant Operation Committee

This committee, formerly known as the Operation Reports Committee, was changed to the Plant Operation Committee by the 1954 Board of Control. The committee, which provides Federal recognition of outstanding operation reports, was created by the Board of Control on October 11, 1941. The committee now administers the William D. Hatfield Award.

M. E. Dawkins, *Chairman*

G. F. Bernauer
W. M. Bingley
W. D. Hatfield
C. W. Klassen

Operator's Qualifications Committee

Authorized by the Board of Control on October 11, 1941, the Operator's Qualifications Committee is assigned to "establish minimal qualifications for operators of various classes of treatment works." The committee also has the duty of collecting and compiling data on present procedures in the licensing and certification of operators for reference to Member Associations.

W. M. Bingley, *Chairman*

W. T. Ballard
Benjamin Benas
T. C. Schaetzle
Sol Seid

Industrial Wastes Committee

The Industrial Wastes Committee was created by the Board of Control on October 23, 1943, for the purpose of developing interest in this important field and to direct a program whereby the Federation may be of service in industrial waste problems.

R. W. Hess, *Chairman*

K. S. Watson, *Vice-Chairman*

R. T. Antrim
R. R. Balmer
E. B. Besselievre
H. H. Black
D. E. Bloodgood
J. M. Brown, Jr.
G. Chanin
Harry Gehm
C. F. Gurnham
W. B. Hart
E. A. Leonard
Kerry Mills
R. W. Ockershausen
L. F. Oeming
G. A. Pettit
H. T. Reuning
R. E. Rostenbach
C. N. Sawyer
J. Wakefield
W. S. Wise

Nominating Committee

The special Nominating Committee was created by the Board of Control on October 9, 1946, to function in an advisory capacity to the Election Committee. The Nominating Committee is to comprise the last five living Past Presidents, with the senior Past President as chairman.

A. H. Niles, *Chairman*

Earnest Boyce
E. Sherman Chase
L. J. Fontenelli
D. B. Lee

Quarter Century Operators' Club Committee

The special Quarter Century Operators' Club Committee was created by the Board of Control on October 9, 1946. It is the function of this Committee to establish eligibility requirements, process membership applications, maintain the roster, and supervise the activities of the Quarter Century Operators' Club.

H. Van Der Vliet, *Chairman*

A. H. Niles Harold W. Streeter

Legislative Analysis Committee

The Legislative Analysis Committee was created by the Board of Control on October 17, 1945, to study legislation pertinent to the interests of the Federation and to serve the Board in advisory capacity.

R. S. Shaw, *Chairman*

J. H. Allen W. W. Gillespie M. LeBosquet
V. W. Bacon R. L. Winget

Constitution and Bylaws Committee

The Constitution and Bylaws Committee was created by the Board of Control on October 10, 1947, to review and develop recommendations for the amendment of the Constitution and Bylaws of the Federation as may be deemed advisable under changing conditions.

G. J. Schroepfer, *Chairman*

A. J. Fischer G. S. Russell
F. S. Friel R. F. Weston
W. J. Orchard W. H. Wisely

Safety Committee

This committee was created in 1954 for the purpose of maintaining close liaison between the Federation and the National Safety Council in the fields common to both organizations.

J. J. Wirts, *Chairman*

G. L. Burt Eric Quartly
U. T. Mann H. A. Schreiber
W. W. Mathews L. W. Van Kleeck

Joint Committees With Other Associations

(Also see Sewage and Industrial Wastes Practice Committee)

Joint Committee on Advancement of Sanitary Engineering

On October 5, 1952 the Board of Control authorized participation in the Joint Committee on Advancement of Sanitary Engineering with the American Society of Civil Engineers, American Water Works Association, American Public Health Association, and American Society for Engineering Education. The objectives of the committee are to study professional recognition of sanitary engineers, educational and training requirements, functional use in public health and military service, opportunities for employment, and similar matters.

FSIWA Representatives

R. E. Lawrence D. F. Metzler R. S. Rankin

Joint Committee on Chlorine Supply

On October 11, 1951, the Board of Control authorized participation in the Joint Committee on Chlorine Supply with the American Water Works Association and the Conference of State Sanitary Engineers. The objective of the committee is to study problems of chlorine supply and distribution in the water and sewage fields, and to develop recommendations for their solution.

FSIWA Representatives

L. H. Enslow
L. L. Hedgepeth

Policy Advisory Committee, APHA Engineering Section

This joint committee was created in 1947 to advise the Council of the Engineering Section, American Public Health Association, on policies and activities of the Section relating to the field of environmental sanitation. Representation on the committee is held by national, regional, and state public health and sanitary engineering organizations.

FSIWA Representative

B. A. Poole

Joint Policy Committee

This joint committee was created in 1954 to provide a unified approach to problems or actions arising by reasons of emergencies or in the common interest. Representation on the committee is held by the Federation, the American Water Works Association, and the Water and Sewage Works Manufacturers' Association.

FSIWA Representatives

E. Sherman Chase
L. J. Fontenelli
W. J. Orchard
R. E. Fuhrman
D. B. Lee

Special Convention Committees

Convention Management Committee

The function of this committee is to supervise details of the management of the Annual Meetings of the Federation.

T. T. Quigley, *Chairman*

H. E. Schlenz
J. G. Stewart
A. A. Appel
R. E. Fuhrman

Meeting Place Committee

This committee reviews invitations received for the Annual Meetings of the Federation and makes recommendations to the Board of Control in regard to the time and place of such meetings.

G. W. Martin, *Chairman*

H. S. Howe
D. B. Lee
J. W. Cunningham
J. A. Frank
J. G. Stewart
R. E. Fuhrman

MEMBERSHIP SUMMARY

(As of December 31, 1955)

Federation Members

Honorary Members	14
Associate Members	71
Member Associations	38
Active Members	6,600
Corporate Members	168

Net Membership of Member Associations *

Member Association	Active	Honorary	Corporate	Total
Alabama	32	—	3	35
Arizona	35	—	3	38
Arkansas	72	—	—	72
California	567	1	8	576
Canadian Inst.	453	1	—	454
Central States	624	3	28	655
Dakota	30	—	—	30
Federal	79	1	—	80
Florida	260	—	—	260
Georgia	128	—	—	128
Germany	38	1	—	39
Iowa	113	—	—	113
ISE (England)	27	—	—	27
ISP (England)	131	1	—	131
Kansas	115	—	1	116
Kentucky-Tennessee	124	—	3	127
Louisiana	8	—	—	8
Maryland-Delaware	74	—	—	74
Michigan	418	—	—	418
Missouri	45	—	1	46
Montana	29	—	4	33
Nebraska	73	—	6	79
New England	379	2	2	383
New Jersey	230	1	—	231
New York	606	1	20	627
North Carolina	145	—	—	145
Ohio	322	—	35	357
Oklahoma	48	—	—	48
Pacific Northwest	301	—	—	301
Pennsylvania	476	2	30	508
Puerto Rico	37	—	—	37
Rocky Mountain	69	—	—	69
South Carolina	43	—	1	44
Sweden	81	—	—	81
Swiss	15	—	—	15
Texas	198	—	1	199
Virginia	105	—	17	122
West Virginia	70	—	5	75
Totals	16,600	14	168	6,782

* Not including Dual Members

MEMBER ASSOCIATIONS

Alabama Water and Sewage Association—Sewage Works Section (Affiliated 1948).

Territory: State of Alabama.
President: C. L. Gray; *Vice-President:* H. O. Snow; *Director:* J. L. Crockett, Jr.; *Treasurer:* D. H. McLean; *Secretary:* W. L. Samuel, c/o B. L. Moore & Co., Box 143, Fairhope, Ala.

Arizona Sewage and Water Works Association—Sewage Works Section (Affiliated 1928).

Territory: State of Arizona.
President: G. T. Rekerdre; *First Vice-President:* M. V. Ellis; *Second Vice-President:* T. Nesbitt; *Director:* J. A. Carollo; *Secretary-Treasurer:* Quentin M. Mees, 721 N. Olsen, Tucson, Ariz.

Arkansas Water and Sewage Conference—Sewage Works Section (Affiliated 1946).

Territory: State of Arkansas.
Chairman: Lon Embree; *Vice-Chairman:* Frank Lewis; *Director:* L. R. Heiple; *Secretary-Treasurer:* Harrison Hale, c/o Southern State College, Magnolia, Ark.

California Sewage and Industrial Wastes Association (Affiliated 1928).

Territory: State of California.
President: H. B. Foster, Jr.; *First Vice-President:* E. V. Quartly; *Second Vice-President:* D. H. Caldwell; *Director:* F. G. Nelson; *Secretary-Treasurer:* J. C. Mallery, 4822 N. Dunsmore Ave., La Crescenta, Calif.

Canadian Institute on Sewage and Sanitation (Affiliated 1933).

Territory: Dominion of Canada.
President: C. G. R. Armstrong; *Vice-President:* L. B. Allan; *Director:* C. A. Anderson; *Secretary-Treasurer:* A. E. Berry, Administrative Office, 72 Grenville St., Toronto 8, Ont., Can.

Central States Sewage and Industrial Wastes Association (Affiliated 1928).

Territory: States of Illinois, Indiana, Wisconsin, and Minnesota.
President: A. J. Duvall; *First Vice-President:* W. E. Ross; *Second Vice-President:* A. P. Troemper; *Third Vice-President:* R. Frazier; *Director:* M. L. Robins; *Secretary-Treasurer:* George F. Bernauer, 713 Chapman St., Madison, Wis.

Dakota Water and Sewage Works Conference—Sewage Works Sections (Affiliated 1936).

North Dakota Section

Territory: State of North Dakota.
President: E. Ostlie; *Vice-President:* E. D. Peterson; *Director:* L. V. Veigel; *Secretary-Treasurer:* Jerome H. Svore, c/o State Dept. of Health, Bismarck, N. Dak.

South Dakota Section

Territory: State of South Dakota.
President: C. Clark; *Vice-President:* L. A. Hericks; *Director:* L. V. Veigel; *Secretary-Treasurer:* Charles E. Carl, c/o Div. of Sanitary Engineering State Board of Health, Pierre, S. Dak.

Federal Sewage Research Association (Affiliated 1930).

Territory: Federal employees wherever stationed.
President: S. C. Martin; *Vice-President:* P. Douderoff; *Director:* L. B. Dworsky; *Secretary-Treasurer:* Keith S. Krause, 9th Floor, 1114 Commerce St., Dallas 2, Texas.

Florida Sewage and Industrial Wastes Association (Affiliated 1941).

Territory: State of Florida.
President: C. E. Richheimer; *Vice-President:* D. B. Smith; *Director:* J. E. Kiker, Jr.; *Secretary-Treasurer:* Emory Dawkins, P. O. Box 4817, Jacksonville 1, Fla.

Georgia Water and Sewage Association—Sewage Works Section (Affiliated 1936).

Territory: State of Georgia.
President: W. W. Kiser; *First Vice-President:* F. L. Futral; *Director:* C. E. Drummond; *Secretary-Treasurer:* A. T. Storey, 1210 Hemphill Ave., N.W., Atlanta, Ga.

German Sewage Technologists Association (Affiliated 1950).

(Abwassertechnische Vereinigung)
Territory: Western Germany.
President: F. Schreier; *Vice-President:* M. Prüss; *Director:* F. Sierp; *Secretary-Treasurer:* O. Pallasch, Theaterstrasse 24, Bonn, Germany.

Institute of Sewage Purification—England (Affiliated 1932).

Territory: British Empire.
President: H. Taylor; *Vice-President:* C. E. Burke; *Director:* W. F. A. Snook; *Secretary:* W. F. A. Snook, 10 Cromwell Place, South Kensington, London S.W. 7, England.

Institution of Public Health Engineers—England (Affiliated 1932).

Territory: British Empire.
President: J. T. Calvert; *Vice-President:* N. J. Tatman; *Director:* W. F. Brown; *Treasurer:* A. Sciver; *Secretary:* Ernest V. Balsom, 118 Victoria St., Westminster, S. W. 1, London, England.

Iowa Sewage and Industrial Wastes Association (Affiliated 1928).

Territory: State of Iowa.
President: V. Garwood; *Vice-President:* K. Hirlinger; *Director:* H. S. Smith; *Secretary-Treasurer:* L. F. Skorezeski, 207 South 15th Ave., Marshalltown, Iowa.

Kansas Sewage and Industrial Wastes Association (Affiliated 1935).

Territory: State of Kansas.
Chairman: L. Beyer; *Vice-Chairman:* D. Eller; *Director:* M. Nelson; *Secretary-Treasurer:* Robert H. Hess, Supt. of Water and Sewage Treatment, City Building, Wichita 2, Kans.

Kentucky-Tennessee Industrial Wastes and Sewage Works Association (Affiliated 1946).

Territory: States of Kentucky and Tennessee.
Chairman: C. M. Davidson; *Vice-Chairman:* L. F. Birkel; *Director:* G. S. Bell; *Secretary-Treasurer:* S. Leary Jones, 420 Sixth Ave., N., Nashville 3, Tenn.

Louisiana Conference on Water Supply and Sewerage—Sewage Works Section (Affiliated 1949).

Territory: State of Louisiana.
Chairman: R. L. Lawrence; *Vice-Chairman:* L. B. Bankston; *Director:* J. L. Love; *Secretary-Treasurer:* George H. West, P. O. Box 15, Lake Charles, La.

Maryland-Delaware Water and Sewage Association—Sewage Works Section (Affiliated 1928).

Territory: States of Maryland and Delaware.
President: T. F. O'Connor; *First Vice-President:* J. Krasauskas; *Second Vice-President:* R. H. Hartman; *Director:* R. H. Ritter; *Secretary-Treasurer:* W. M. Bingley, 2411 N. Charles St., Baltimore 18, Md.

Michigan Sewage and Industrial Wastes Association (Affiliated 1930).

Territory: State of Michigan.
President: M. P. Adams; *First Vice-President:* F. W. Galamon; *Second Vice-President:* G. McBride; *Director:* R. A. Greene; *Secretary-Treasurer:* D. M. Pierce, Michigan Dept. of Health, Room 334, Administration Bldg., Lansing 4, Mich.

Missouri Water and Sewerage Conference—Sewage Works Section (Affiliated 1929).

Territory: State of Missouri.
Chairman: E. G. Lee; *Vice-Chairman:* F. McAndrew; *Director:* J. K. Smith; *Secretary-Treasurer:* Warren A. Kramer, c/o State Office Bldg., Sixth Floor, Jefferson City, Mo.

Montana Sewage and Industrial Wastes Association (Affiliated 1944).

Territory: State of Montana.
Chairman: M. F. Dixon; *Vice-Chairman:* R. Setterstrom; *Director:* F. F. Palmer; *Secretary-Treasurer:* Harvey W. Taylor, Morrison & Maierle, Inc., Helena, Mont.

Nebraska Sewage and Industrial Wastes Association (Affiliated 1952).

Territory: State of Nebraska.
President: W. F. Rapp, Jr.; *Vice-President:* V. H. Black; *Director:* D. R. Hill; *Secretary-Treasurer:* V. J. Lechtenberg, 614 Standard Oil Bldg., Omaha, Nebr.

New England Sewage and Industrial Wastes Association (Affiliated 1929).

Territory: States of Maine, New Hampshire, Vermont, Massachusetts, Connecticut, and Rhode Island.
President: J. H. L. Giles; *First Vice-President:* C. N. Sawyer; *Second Vice-President:* J. MacDonald; *Director:* W. S. Wise; *Secretary-Treasurer:* Henry F. Munroe, 75 Paine Ave., Cranston 10, R. I.

New Jersey Sewage and Industrial Wastes Association (Affiliated 1942).

Territory: State of New Jersey.
President: John Collom; *First Vice-President:* A. Palmer; *Second Vice-President:* R. J. Budrick; *Director:* S. Seid; *Secretary-Treasurer:* Michael S. Kachorsky, P. O. Box 766, Manville, N. J.

New York Sewage and Industrial Wastes Association (Affiliated 1930).

Territory: State of New York.
President: J. M. Brown, Jr.; *Vice President:* R. Thomas; *Director:* A. J. Fischer; *Treasurer:* J. C. Brigham; *Secretary:* R. C. Sweeney, c/o State Dept. of Health, 21 N. Broadway, White Plains, N. Y.

North Carolina Sewage and Industrial Waste Association (Affiliated 1929).

Territory: State of North Carolina.
Chairman: R. S. Phillips; *Vice-Chairman:* C. Mengel; *Director:* E. C. Hubbard; *Secretary-Treasurer:* W. E. Long, Jr., Box 2091, Raleigh, N. C.

Ohio Sewage and Industrial Wastes Treatment Conference (Affiliated 1932).

Territory: State of Ohio.
Chairman: G. A. Pettit; *First Vice-Chairman:* F. Ruck; *Second Vice-Chairman:* W. R. Taylor; *Director:* G. A. Hall; *Secretary-Treasurer:* Ward E. Conrad, 301 Ohio Depts. Bldg., Columbus 15, Ohio.

Oklahoma Water, Sewage and Industrial Waste Conference—Sewage Works Section (Affiliated 1929).

Territory: State of Oklahoma.
President: R. J. Linde; *Vice-President:* R. E. Fagan; *Director:* C. E. Montrey; *Secretary-Treasurer:* H. M. Crane, State Dept. of Health, 3400 N. Eastern, Oklahoma City 5, Okla.

Pacific Northwest Sewage and Industrial Wastes Association (Affiliated 1933).

Territory: States of Washington, Oregon, and Idaho.
President: E. F. Eldridge; *Vice-President:* A. J. Wahl; *Director:* E. C. Jensen; *Secretary-Treasurer:* Walter W. Saxton, 408 Old Capitol Bldg., Olympia, Wash.

Pennsylvania Sewage and Industrial Wastes Association (Affiliated 1928).

Territory: State of Pennsylvania.
President: L. L. Gwin; *First Vice-President:* G. A. Elias; *Second Vice-President:* B. S. Bush; *Director:* R. F. Weston; *Secretary-Treasurer:* J. R. Harvey, Regional San. Engr., Pennsylvania Dept. of Health, 916 Diamond, Meadville, Pa.

Puerto Rico Water and Sewage Works Association (Affiliated 1947).

Territory: Puerto Rico.
President: E. F. Saavedro; *Vice-President:* R. Bras; *Director:* L. R. Robles; *Secretary-Treasurer:* Robert J. Auld, c/o Puerto Rico Aqueduct and Sewer Authority, Box 2832, San Juan 12, Puerto Rico.

Rocky Mountain Sewage Works Association (Affiliated 1947).

Territory: States of Wyoming, Colorado, and New Mexico.
President: W. F. Turner; *Vice-President:* R. L. Streeter; *Director:* B. V. Howe; *Secretary-Treasurer:* John R. Peterson, 376 City and County Bldg., Denver 2, Colo.

South Carolina Water and Sewage Works Association—Sewage Works Section (Affiliated 1949).

Territory: State of South Carolina.
Chairman: F. M. Gibson; *Vice-Chairman:* R. G. Pennington; *Director:* E. D. Frye, Jr.; *Secretary-Treasurer:* T. A. Kolb, 1329 Ellison Rd., Columbia, S. C.

Swedish Association for Water Hygiene (Affiliated 1952).

(Föreningen För Vattenhygien)
Territory: Sweden.
President: A. Myrgård; *Vice-President:* M. Wennström; *Director:* N. Westberg; *Secretary-Treasurer:* Erik Jonsson, Box 5038, Stockholm 5, Sweden.

Swiss Association of Water and Sewage Professionals (Affiliated 1947).

(Verband Schweizerischer Abwasserfachleute)
Territory: Switzerland.
President: F. Baldinger; *Vice-President:* A. Hoerler; *Director:* P. Wildi; *Treasurer:* E. Holinger; *Secretary:* Pierre Wildi, Hegenmatt 28, Zurich, Switzerland.

Texas Water and Sewage Works Association—Sewage and Industrial Wastes Section (Affiliated 1928).

Territory: State of Texas.
Chairman: W. S. Mahlie; *First Vice-Chairman:* J. L. Reagan; *Second Vice-Chairman:* G. A. Doty; *Director:* C. H. Connell; *Secretary:* V. M. Ehlers, 2202 Indian Trail, Austin, Tex.; *Assistant Secretary and Treasurer:* Mrs. E. H. Goodwin.

Virginia Industrial Wastes and Sewage Works Association (Affiliated 1947).

Territory: State of Virginia.
President: W. R. McCann; *Vice-President:* J. J. Corballis, Jr.; *Director:* B. L. Strother; *Secretary-Treasurer:* J. L. Hamrick, Jr., 415 W. Franklin St., Richmond 20, Va.

West Virginia Sewage and Industrial Wastes Association (Affiliated 1947).

Territory: State of West Virginia.
President: T. K. Bruce; *First Vice-President:* J. W. Lester; *Second Vice-President:* P. T. Arbuckle; *Director:* H. K. Gidley; *Secretary-Treasurer:* Glen O. Fortney, State Dept. of Health, Charleston 5, W. Va.

HONORARY MEMBERS

Berry, Albert E. (1954), Director, Ontario Dept. of Health, San. Eng. Div., 235 Gainsboro Rd., Toronto 8, Ont., Can.

DeBerard, Wilford Willis (1950), Dep. Commr. of Water and Ch. Water Engr., Bur. of Eng., Dept. of Pub. Works, 402 City Hall, Chicago 2, Ill.

Fair, Gordon Maskew (1955), Head, Dept. of San. Eng., Harvard Univ., Cambridge 38, Mass.

Gilcreas, F. Wellington (1948), Prof. of San. Sc., Univ. of Fla., Gainesville, Fla.

Hyde, Charles Gilman (1943), Cons. Engr., 2495 Shattuck Ave., Berkeley 4, Calif.

Imhoff, Karl (1953), Cons. Engr., Robert Schmidt Str. 8, Essen, Germany.

Lockett, William T. (1954), Chief Chemist, Middlesex County Main Drainage Works, Oak Lane, Isleworth, Middlesex, Eng.

Mohlman, Floyd W. (1944), Dir., Div. of Lab., Sanitary Dist. of Chicago, 910 S. Michigan Ave., Chicago 5, Ill.

Moses, Howard E. (1943), Cons. Engr., State Dept. of Health, 1522 N. Second St., Harrisburg, Pa.

Orchard, William J. (1946), Wallace & Tiernan Co., Inc., Newark 1, N. J.

Pearse, Langdon (1942), Sanitary Engr., Sanitary Dist. of Chicago, 910 S. Michigan Ave., Chicago 5, Ill.

Rudolfs, Willem (1945), Huzarenlaan, Joppe (Geld), The Netherlands.

Streeter, Harold W. (1953), Box 192, R.R.1, Old Indian Hill Rd., Cincinnati 27, Ohio.

ASSOCIATE MEMBERS

ACF Industries, Inc., 1501 E. Ferry Ave., Detroit 11, Mich., Rep. William A. Gormley, Sales Mgr., Valve Div.

Airkem, Inc., 241 East 44th St., New York 17, N. Y., Rep. J. M. von Bergen.

American Cast Iron Pipe Co., Birmingham, Ala., Rep. A. J. Hellman.

American City Magazine, 470 Fourth Ave., New York, N. Y., Rep. Edgar J. Buttenheim, Pres.

American Concrete Pipe Assn., 228 N. LaSalle St., Suite 1033, Chicago 1, Ill., Rep. Howard F. Peckworth, Managing Dir.

American Well Works, 100 N. Broadway, Aurora, Ill., Rep. L. H. Kramer, Exec. Vice-Pres.

Armco Drainage & Metal Products, Inc. (Armco Steel Corp.), Middletown, Ohio, Rep. W. H. Spindler, Pub. Mgr.

B-I-F Industries, Inc., 345 Harris Ave., Providence, R. I., Rep. G. W. Kelsey, Vice-Pres.

Carter, Ralph B., Co., 192 Atlantic St., Hackensack, N. J., Rep. J. J. Horgan.

Chain Belt Co., P. O. Box 2022, Milwaukee 1, Wis., Rep. R. T. Steindorf.

Chapman Valve Mfg. Co., 203 Hampshire St., Indian Orchard, Mass., Rep. John H. Sheehan.

Chicago Pump Co., 622 Diversey Parkway, Chicago 14, Ill., Rep. Milton Spiegel, Vice-Pres.

Climax Engine & Pump Mfg. Co., 208 N. LaSalle St., Chicago 4, Ill., Rep. E. D. West, Mgr.

Combustion Engineering, Inc., Raymond Pulverizer Div., 1315 N. Branch St., Chicago 22, Ill., Rep. C. W. Gordon, Mgr.

Crane Co., 836 S. Michigan Ave., Chicago 5, Ill., Rep. J. W. Bowe.

DeZurik Shower Co., Sartell, Minn., Rep. David DeZurik.

Dorr-Oliver Inc., Barry Pl., Stamford, Conn.

Elmco Corp., 301 S. Hicks Rd., Palatine, Ill., Rep. Paul O. Richter, Mgr., Central Div.

Engineering News-Record, 330 W. 42nd St., New York 36, N. Y.

Everson Mfg. Co., 214 W. Huron St., Chicago 10, Ill., Rep. R. B. Everson, Pres.

Fairbanks, Morse & Co., 3601 Kansas Ave., Kansas City, Kans., Rep. T. E. Woodruff.

Fischer & Porter Co., Hatboro, Pa., Rep. Jack Burke.

Flexible Sales Corp., 3786 Durango Ave., Los Angeles 34, Calif., Rep. Peter L. Ciaccio, Mgr.

Foxboro Co., Util. Ind. Div., Foxboro, Mass., Rep. Russell H. Babcock, Asst. Mgr.

Gale Separator Co., Inc., 2 Broad St., Bloomfield, N. J., Rep. William A. Gehle, Pres.

General Electric Co., 1 River Rd., Schenectady 5, N. Y., Rep. E. O. Pothoff.

General Laboratory Supply Co., P. O. Box 2607, Paterson, N. J., Rep. I. T. Klein.

Gruendler Crusher & Pulverizer Co., 2915 N. Market St., St. Louis 6, Mo., Rep. William P. Gruendler.

Hardinge Co., York, Pa., Rep. M. C. Fleming.

Hersey Mfg. Co., Corner of E. and Second Sts., S. Boston 27, Mass., Rep. William C. Sherwood.

Homestead Valve Mfg. Co., Box 348, Coraopolis, Pa. Rep. F. E. Schuchman.

Industrial Materials Co., Somerset St. & Trenton Ave., Philadelphia 34, Pa., Rep. John M. Riordan, Pres.

Inertol Co., Inc., 480 Frelinghuysen Ave., Newark 5, N. J., Rep. G. W. Rupp.

Infilco Inc., 2750 12th Ave., S., Tucson, Ariz., Rep. H. W. Gillard.

Jeffrey Mfg. Co., Columbus 16, Ohio, Rep. S. L. Tolman.

Johns-Manville Corp., 22 E. 40th St., New York 16, N. Y., Rep. R. F. Orth.

Josam Mfg. Co., Michigan City, Ind., Rep. Leo N. Newman.

Komline-Sanderson Eng. Corp., P. O. Box 257, Peapack, N. J., Rep. T. R. Komline, Pres.

Koppers Co., Inc., Tar Products Div., Pittsburgh 19, Pa., Rep. M. K. Cox.

Lakeside Eng. Corp., 222 W. Adams St., Chicago 6, Ill., Rep. R. O. Friend.

Link-Belt Co., Colmar Plant, Colmar, Pa., Rep. B. K. Hartman.

Lock Joint Pipe Co., E. Orange, N. J., Rep. F. F. Longley, Vice-Pres.

Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh 8, Pa., Rep. N. R. Chillingworth.

Minneapolis-Honeywell Regulator Co., Wayne & Windrim Aves., Philadelphia 44, Pa., Rep. W. H. Sisson, Industry Mgr.

Morse Boulger Destructor Co., Sewage & Waste Div., 80 Fifth Ave., New York 11, N. Y.

Mueller Co., 512 W. Cerro Gordo St., Decatur, Ill., Rep. R. H. Morris.

National Water Main Cleaning Co., 50 Church St., New York, N. Y., Rep. J. A. Frank, Pres.

Nichols Eng. & Research Corp., 60 Wall Tower, New York 5, N. Y., Rep. R. W. Rowen.

Pacific Flush Tank Co., 4241 Ravenswood Ave., Chicago, Ill., Rep. L. E. Rein.

Penn Instruments Division, Burgess-Manning Co., 4110 Haverford Ave., Philadelphia 4, Pa., Rep. Wm. C. Bennett.

Pittsburgh Coke and Chemical Co., P. O. Box 1645, Pittsburgh 30, Pa., Rep. J. G. Birch.

Pittsburgh-Des Moines Co., Neville Island Branch, Pittsburgh 25, Pa., Rep. L. E. O'Leary.

Pittsburgh Equitable Meter Division, Rockwell Manufacturing Co., 400 N. Lexington Ave., Pittsburgh, Pa., Rep. J. F. O'Grady.

Pittsburgh Pipe Cleaner Co. of N. Y., Inc., 990 Broad St., Newark, N. J., Rep. Kyle I. Robinson, Pres.

Preload Co., Inc., 211 E. 37th St., New York 16, N. Y., Rep. E. H. Thwaits, Vice-Pres.

Price Brothers Co., 1932 E. Monument Ave., P. O. Box 825, Dayton 1, Ohio, Rep. Harry S. Price, Jr.

Public Works Magazine, 200 S. Broad St., Ridgewood, N. J., Rep. W. A. Hardenbergh.

Royer Foundry and Machine Co., 158 Pringle St., Kingston, Pa., Rep. S. B. Davies, Pres.

Simplex Valve & Meter Co., 7 E. Orange St., Lancaster, Pa., Rep. Everett M. Jones, Sales Mgr.

Smith, A. P., Mfg. Co., 545 N. Arlington Ave., E. Orange, N. J., Rep. W. P. Baerenrodt.

Stuart Corp., 516 N. Charles St., Baltimore, Md., Rep. Fred E. Stuart, Sr.

Vapor Recovery Systems Co., 2820 N. Alameda St., Compton, Calif., Rep. F. V. Long, Pres.

Walker Process Equipment, Inc., Aurora, Ill., Rep. J. D. Walker, Pres.

Wallace & Tiernan Co., Inc., 25 Main St., Belleville 9, N. J., Rep. T. T. Quigley.

Warren Foundry & Pipe Corp., 55 Liberty St., New York 5, N. Y., Rep. Frank Marold.

Wastes Engineering, 305 E. 45th St., New York 17, N. Y., Rep. Earl M. Mann.

Water & Sewage Works, 185 N. Wabash Ave., Chicago 1, Ill., Rep. E. S. Gillette.

Western Machinery Co., 760 Folsom St., San Francisco 7, Calif., Rep. Wm. H. Newton.

Westinghouse Electric Corp., P. O. Box 146, Pittsburgh 30, Pa., Rep. J. D. Witherspoon.

Worthington Corp., Harrison, N. J., Rep. C. K. Hood, Vice-Pres.

Yeomans Brothers Co., 1999 N. Ruby St., Melrose Park, Ill., Rep. Charles Yeomans, Pres.

CONSOLIDATED MEMBERSHIP DIRECTORY *

Aarons, Aaron, Mun. Engr., City Hall, Los Angeles 12, Calif. (Calif.)

Abel, C. F., Mun. Engr., Allegheny Co. San. Auth., 4501 Center Ave., Pittsburgh 13, Pa. (Pa.)

Abell, DeWitt S., Dist. San. Engr., State Dept. of Health, Greenwood Village, R. D. 5, Butler, Pa. (N.Y.)

Abington Twp. Pub. Wks. Dept., Att: Oliver L. King, Twp. Engr., 1176 Old York Rd., Abington, Pa. (Pa.)

Abplanalp, C. C., Dist. Mgr., Wallace & Tiernan Co., Inc., 1229 W. Washington Blvd., Chicago 7, Ill. (Cen. St.)

Abplanalp, G. H., Prin. Engr., Havens & Emerson, 233 Broadway, New York 7, N. Y. (N.J.)

Aby, C. W., Chem., San Rafael San. Dist., 30 "H" St., San Rafael, Calif. (Calif.)

Ace Pipe Cleaning, Inc., 3513 E. 18th St., Kansas City, Mo. (Mo.)

Acevedo-Quintana, F., San. Engr., Inst. Nacional de Obras Sanitarias, Edificio Araure—Oficina No. 202, Calle Real Sabana Grande, Caracas, Ven., S. A. (P.R.)

Acks, William F., Plt. Mgr., Bechtel-McLaughlin, Inc., P. O. Box 948, Sandusky, Ohio (Ohio)

Adair, Duncan L., Village Engr. & Pub. Wks. Supt., Mun. Bldg., Sidney, N. Y. (N.Y.)

Adams, Charles L., Sr. San. Chem., San. Dist. of Chicago, 3721 Kemman Ave., Brookfield, Ill. (Cen. St.)

Adams, Clarence D., Water Plt. Supt. & Cons. Chem. Eng., P. O. Box 307, New Albany, Ind. (Cen. St.)

Adams, George R., Supt., Sewage Trt. Plt., Lawrence, Ind., 2802 N. Dearborn St., Indianapolis, Ind. (Cen. St.)

Adams-Hydraulics, Ltd., Peasholme Green, York, England (ISP)

Adams, J. K., Supt., Bergen Co. Sewer Auth., 16 Knoll Rd., Tenafly, N. J. (N.J.)

Adams, J. W., Supt. of Water & Sewage, 124 E. Main St., Carlinville, Ill. (Cen. St.)

Adams, John M., Prin. San. Engr., Tenn. Dept. of Pub. Health, 602 Cordell Hull Bldg., Nashville 3, Tenn. (Ky.-Tenn.)

Adams, Milton P., Sec., State Stream Control Comm., P. O. Box 87, Lansing 1, Mich. (Mich.)

Adams, Ray, Water & Sewage Dept., Thomaston, Ga. (Ga.)

Adams, Robert R., Hd., Chem. Dept., J. E. Sirrine Co., Greenville, S. C. (S.C.)

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Versailles: M. L. Straker
Walbridge: H. M. Johnson
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Youngstown: L. C. Flickinger, M. L. Riehl
Zanesville: Armco Steel Corp., L. H. Reed

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Miami: J. T. Sprague
Midwest City: L. B. Wolfenson

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Norman: T. L. Morrow
Nowata: M. L. Hutton
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Ponca City: F. Fellow, J. S. Hume
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Stillwater: L. C. DeCory, Q. B. Graves
Tulsa: J. A. Graves, R. P. Kuykendall, R. Linde, C. L. Mansur, C. E. Moutrey, B. V. Prather, W. E. Ruland, N. A. Tandy, W. W. Wheeler

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Milton-Freewater: N. H. Gilmore
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Milton: American Home Foods, Inc.
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Monroeville: T. F. Reed
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New Hope: W. Pfeffer
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Norristown: J. L. Dzedzy
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Oakmont: T. Douglass
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Pocono Manor: C. E. James
Polk: L. A. McKissick
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Royersford: C. A. Moore
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Sharon Hill: H. G. Damon, A. W. Holbrook
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Simpson: A. Bambara
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Brighton: C. J. Regan
Bury: G. R. C. Marsden
Buxton: K. McDonald
Cambridge: H. Clay
Chatham: J. B. Harvey
Chertsey: E. C. Stoker
Chestnut: F. W. Swain
Coventry: C. B. O. Jones
Crawley: L. T. Dowling
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Dideot: T. G. Faulkner
Doncaster: L. Kitchen
Durham: M. Gibson, J. S. McCue
Epsom: H. H. Stanbridge
Finedon: E. Flowers
Gloucester: L. J. Jarvis
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Halifax: C. Lumb
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Heywood: J. F. Bolton
Horley: E. McG. Weir
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Hythe: C. K. F. Watson
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Ipswich: A. E. Chapman, J. B. Storey
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Launceton: A. M. A. Bowrey
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Maidenhead: J. Stanbridge
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Melton Mowbray: L. Hesford
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Northampton: F. J. Cave
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Sheffield: J. H. Edmonson
Shipley: W. H. Hillier
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Somerset: L. Gill
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Walsall: J. P. Barnes
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Dumfries: C. P. James
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Galashiels: J. I. Waddington
Glasgow: J. McL. Fraser
Motherwell: D. H. Barraclough, W. E. Templeton
Stirling: W. F. Collett

Wales

Wrexham: Dr. I. S. Wilson

HOLLAND

Amsterdam: H. W. D. Zee, C. E. Moxmann
Bussum: J. M. J. W. Wijdenes
The Hague: J. W. Bell, H. Kessener
Joppe: W. Rudolfs

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Haifa: P. S. Goldschmidt
Jerusalem: H. J. Hordes

JAPAN

Tokyo: I. Horasawa

JORDAN

Amman: R. D. Lee

KENYA

Nairobi: B. G. D. Kirk

MALAYA

Singapore: L. H. T. Caulfield

MEXICO

Coyoacan: H. R. Alvarez
Mexico City: A. Lasaga, C. E. Richey

NICARAGUA

Matagalpa: J. Hayn

NEW ZEALAND

Auckland: Auckland Metropolitan Drainage Board, R. Hicks

NORWAY

Oslo: K. Baalsrud

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SAUDI ARABIA

Dhahran: J. G. Cassanos

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Vryburg, Cape Province: B. V. H. Rose

SURINAM

Paramaribo: R. Brewer

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Abrahamsberg: B. Holm
Boras: A. af Ekenstam, A. Fagrell, I. Jarnegren, A. Lindgren
Bromma: H. Holmquist, E. Kruse
Djursholm: G. Akerlindh
Drottningholm: B. Stendahl
Enskede: N. Kristoffersson, A. Orrje, B. Ward
Eskilstuna: B. Rithander
Falun: O. Ullerstam
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Hagersten: S. Hellgren, Y. Thorell
Halsingborg: E. Franzen, B. Retzner
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Zurich: A. Horler, A. Kropf, H. Kuisel, F. Schneiter, P. Wildi, P. Zigerli

SYRIA

Aleppo: M. B. Al-Hakim

THAILAND

Bangkok: E. W. Steel

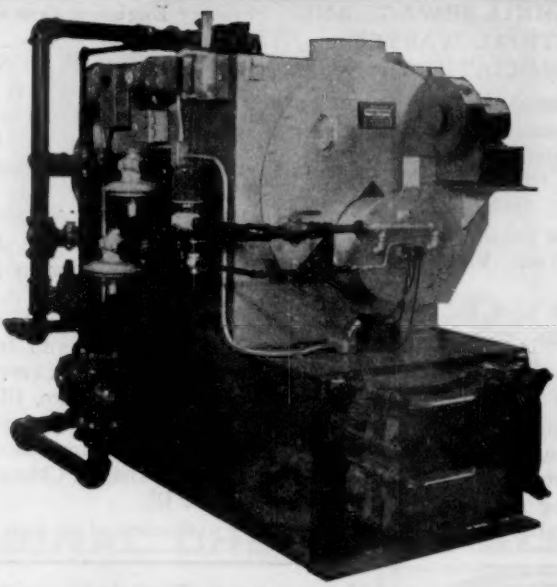
VENEZUELA

Caracas: F. Acevedo-Quintana, G. M. Disario, L. E. Garcia-Pena, H. Hall, Jr., R. M. Harris, J. M. Hepler, J. R. Hurtado
Maracaibo: G. P. Hanna, Jr.

WALKER PROCESS

HEATX UNIT

Digester Heat Exchanger



370,000 BTU/hr. HEATX for installation at Villa Park, Illinois. Burner automatically utilizes sewage gas or natural gas separately or in combination. A pre-ignition purge cycle clears the combustion chamber of any fuel accumulation before starting or between fuel switch-over.

FORCED TURBULENT CIRCULATION
HIGH RATE OF HEAT TRANSFER
NO SLUDGE ADHESION

The HEATX is designed to allow absolute and independent control over each function of sludge heating; namely, heating of jacket water, control of temperature and flow of jacket water and control of digester temperature and rate of turnover.

The HEATX is offered as either a separate exchanger, for use with existing standard boilers or as a package unit complete with a Walker Process boiler and burner. Boilers are designed to burn sewage gas, sewage gas and oil or sewage gas and natural gas.

The concentric tube type exchanger is equipped with special removable end castings arranged to prevent contamination of the heating water by material circulated through the sludge tubes.

Write for Bulletin 24S82.

Engineering and manufacturing a complete line of water, waste and sewage treatment equipment.

WALKER PROCESS

WALKER PROCESS EQUIPMENT INC.
Factory — Engineering Offices — Laboratories
Aurora, Illinois

Proceedings of Member Associations

WEST VIRGINIA SEWAGE AND INDUSTRIAL WASTES ASSOCIATION

The 9th Annual Meeting of the West Virginia Sewage and Industrial Wastes Association was held at the Waldo Hotel, Clarksburg, W. Va., on October 19–20, 1955, with part of the program being participated in jointly with the West Virginia Section, AWWA.

Among the technical papers presented were the following:

"Sewers or Septic Tanks in Subdivisions," by James H. LeVan, Zone Sanitary Engineer, Federal Housing Administration, Jamaica, L. I., N. Y.

"Pilot Plant Evaluation of a Plastic Tower Packing as a Trickling Filter Medium," by Dr. Edward H. Bryan, Sanitary Engineer, Dow Chemical Co., Midland, Mich.

"Basic Approach to Waste Treatment Problems," by I. B. Remsen, Jr., Herr-Harris Co., Pittsburgh, Pa.

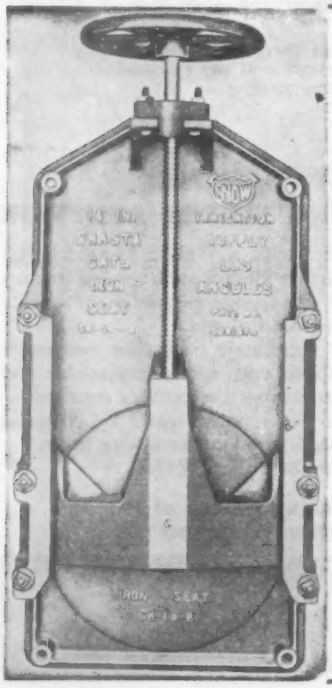
"Densludge Process," by Roy Dragone, Sales Engineer, Dorr-Oliver Co., Baltimore, Md.

"Principles of Dissolved Air Flotation," by Dr. William J. Katz, Research and Development Dept., Chain Belt Co., Milwaukee, Wis.

"Flash Drying of Sewage Sludge and Flash Drying and Incineration," by Claude A. Leet, Combustion Engineering, Inc., Chicago, Ill.

"New Type of Sewage Plant for Small and Medium Sized Projects," by Paul M. Thayer, Chicago Pump Co., Chicago, Ill.

(*Continued on page 120a*)



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All types of cast iron gates manufactured in either square or circular opening in sizes up to and including 72 inches.

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A 25th plant is being added to General Chemical's coast-to-coast network of aluminum sulfate production centers! The new liquid alum plant at Hopewell, Va. will serve paper mills and water and sewage treatment plants in the area . . . just as General's other facilities provide for needs of consumers near them.

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Sewage treatment progress in West Virginia communities was presented in reports of city officials from Charleston, Clarksburg, Wheeling, Parkersburg, Madison, Princeton, and Huntington.

At the joint meeting with the West Virginia Section, AWWA, the following papers were presented:

"Trials and Tribulations of a Realtor in Obtaining Water and Sewer Service from a Municipality," by S. L. Bracken, Real Estate Developer, Fairmont, W. Va.

"Looking Ahead—Water Supply and Waste Treatment Problems in the Atomic Age," by Dr. Richard L. Woodward, Chief, Water Supply Unit, USPHS, Cincinnati, Ohio.

"Modern Mapping Techniques," by Robert A. Cummings, Jr., Robert A. Cummings, Jr. & Associates, Pittsburgh, Pa.

"The Consulting Engineer's Responsibility After Construction of a Plant Has Been Completed," by Edward F. Twomey, Consulting Engineer, Morris-Knowles, Inc., Pittsburgh, Pa.

The following officers were elected for the ensuing year:

President: Thomas K. Bruce, Bluefield.

1st Vice-President: John W. Lester, Charleston.

2nd Vice-President: Paul T. Arbuckle, Nitro.

Secretary-Treasurer: Glen O. Fortney, Charleston.

GLEN O. FORTNEY,
Secretary-Treasurer

FLORIDA SEWAGE AND INDUSTRIAL WASTES ASSOCIATION

The 1955 Annual Meeting of the Florida Sewage and Industrial Wastes

(*Continued on page 121a*)

Sterelators by Everson

CHLORINE CONTROL
APPARATUS
VACUUM SOLUTION FEED

METER AND CONTROL CHLORINE GAS IN THE NON-CORROSIVE STATE

EVERSON STERELATORS are so designed that the basic unit remains unchanged but by the addition of various controls, can be adapted to perform added functions.

MANUAL CONTROL: The manually controlled solution feed vacuum type Sterelator is the basic unit.

SEMI-AUTOMATIC CONTROL: For on-and-off chlorinating periods.

FULL AUTOMATIC PROPORTIONING CONTROL: Air operated, proportions gas flow to water flow.

CYCLE CONTROL: with timing devices for definite and adjustable chlorinating cycles.

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REPRESENTATIVES IN PRINCIPAL CITIES

Association was held at the Orange Court Hotel, Orlando, Fla., November 6–9, 1955, jointly with the meeting of the Florida Section, AWWA. A registration of almost 300 marked the 43 per cent growth of the Association since the previous meeting.

Two highlights of the program were forums on "Planning and Policies for Extending Water and Sewage Facilities Beyond City Limits," moderated by A. E. O'Neall, Consulting Engineer, Orlando, and "Construction and Maintenance of Sewage Collection Systems," moderated by A. W. Saarinen, Philpott, Ross & Saarinen, Fort Lauderdale.

Some of the technical papers of primary interest to the sewage and industrial wastes group attending the joint meeting included:

"Report on Findings of the Governor's Committee on Water Resources," by Byron E. Herlong, Chairman, State Water Resources Study Commission, Leesburg.

"Economics of Water Supplies and Sewerage in Florida," by L. C. Leedy, Jr., Leedy, Wheeler and Alleman, Orlando.

"Value of Standard Methods in Plant Operations," by F. W. Gilcreas, Professor of Sanitary Science, University of Florida, Gainesville.

"Factors in Citrus Wastes Purification," by Dr. James B. Lackey, Professor of Sanitary Science, University of Florida, Gainesville, with discussion by Dr. R. R. McNary, Research Fellow, Florida Citrus Commission, Lake Alfred.

"The Ocala Story," by G. D. Russell and F. T. Osteen, Jr., Russell and Axon, Daytona Beach.

"The Training Program of the Robert A. Taft Sanitary Engineering Center," by H. P. Kramer, Chief of Training USPHS, Cincinnati, Ohio.

"Water Requirements of Florida Industries," by F. A. Eidsness, Black & Associates, Gainesville.

(*Continued on page 122a*)

"Stream Sanitation in Florida," by J. W. Wakefield, Florida State Board of Health, Jacksonville.

"Tuxedos and Tennis Shoes in Modern Utilities and Industry," by John B. Prine, Reynolds, Smith and Hills, Jacksonville.

"Atmospheric Pollution," by Dr. E. R. Hendrickson, University of Florida, Gainesville.

"Design of the Complete Sewage Treatment Plant for the Florida State Farm Colony, and Operational Results," by Lewis S. Shields, Jr., Reynolds, Smith and Hills, Jacksonville.

"Problems of Radioactive Waste Disposal," by Conrad P. Straub, Oak Ridge National Laboratory, Oak Ridge, Tenn.

"The Rates of Oxygen Uptake in the B.O.D.," by Dr. A. M. Buswell, Research Professor of Chemistry, University of Florida, Gainesville.

"Development of Private Utilities Companies," by J. W. Greenleaf, Jr., Rader Engineering Company, Miami.

John S. Whitney was presented the L. H. Scott Memorial Award as outstanding operator member of the year. Dr. David B. Smith was honored for his three years of service as Program Chairman.

Officers elected for 1955–56 are as follows:

President: Charles E. Richheimer, Jacksonville.
Vice-President: David B. Smith, Gainesville.
FSIWA Director: John W. Wakefield, Jacksonville.
Secretary-Treasurer: M. E. Dawkins, Jacksonville.

M. E. Dawkins,
Secretary-Treasurer

(*Continued on page 123a*)

DeZURIK VALVES IN 3 SAN FRANCISCO SEWAGE PLANTS

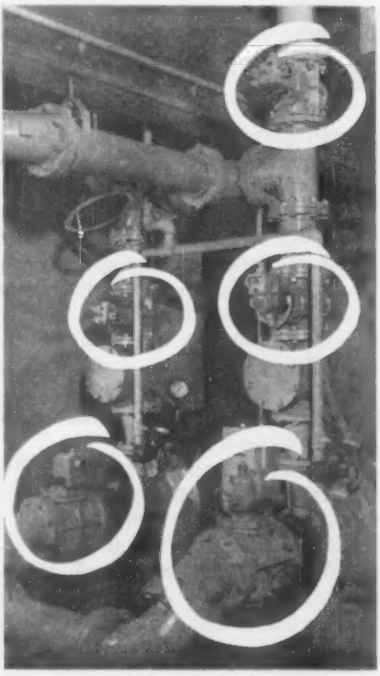
The City of San Francisco has installed DeZurik Easy-Operating Non-Lubricated Plug Valves in three municipal sewage plants. The installation pictured shows DeZurik Valves on raw sewage influent lines in the South East Plant.

In sewage plants all over the country, DeZurik Valves are being specified for new installations—are replacing ordinary valves in existing systems.

Exclusive eccentric action, easy quarter-turn to open or close, no lubrication—these are a few of the many reasons for the growing use of DeZurik Plug Valves in modern sewage plants.

Write for more details. Representatives in principal cities.

DeZURIK SHOWER CO.
SARTELL, MINN.



NORTH CAROLINA SEWAGE AND INDUSTRIAL WASTE ASSOCIATION

The 1955 Annual Meeting of the North Carolina Sewage and Industrial Waste Association was held jointly with the North Carolina Section, AWWA, at the Robert E. Lee Hotel, Winston-Salem, N. C., on November 14–16, 1955. Attendance of approximately 300 was recorded.

Papers of interest to sewage works personnel included:

"Winston-Salem's Sewer Expansion Program," by P. D. Davis, Consulting Engineer, Piatt and Davis, Durham.

"The Development of the Stream Sanitation Program for the Yadkin River Basin," by E. C. Hubbard, Executive Secretary, State Stream Sanitation Committee, North Carolina State Board of Health, Raleigh.

An interesting symposium on the treatment of industrial wastes with domestic sewage was conducted by Professor M. L. Granstrom, University of North Carolina.

A paper of interest to both water and sewage works personnel was presented by George S. Rawlins, Vice-President, J. N. Pease & Co., Charlotte, on "Relocation of Utilities for Highway Improvements.". Discussions were presented by officials of several municipal water and sewerage facilities.

The Federation's Arthur Sidney Bedell Award was presented to P. D. Davis of Durham by Federation Past-President, David B. Lee.

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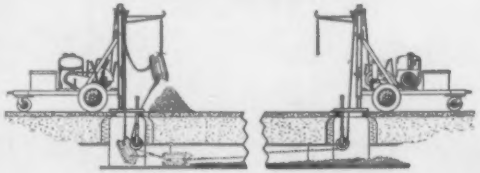

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